Uncertainty Propagation and Environmental Input-Output Modelling: Evidence from Russia

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Abstract

Combustion of fossil fuels accounts for the large majority of the global greenhouse gas emissions. Russia is a major producer of fossil fuels and hence one of the leaders in anthropogenic greenhouse gas emissions. A significant body of literature incorporates Russia within a multi-regional framework, but no comprehensive study assessed its role in a single-region setting. The aim of this thesis is to study the production structure of the Russian economy, its embodied carbon emissions, and the drivers of the embodied emission changes over the course of 1980-2013. To accomplish this objective, input-output modeling methodology and the data from two different national sources are utilized. Due to concerns about the quality of national data, comprehensive sensitivity tests are carried out on derived input-output multipliers to stochastic perturbations using Monte Carlo simulation approach and norm theory. It is shown that the underlying input-output system is well-behaved. Multipliers are stable and converge to the long-run equilibrium similar to those derived from German data as well as the WIOD and Eora databases. Through the application of input-output modeling methodology we provide a comprehensive study of the underlying inter-industrial relations which characterize the flow structure and the technology state of the Russian economy. Thereafter, we employ an environmentally extended input-output modeling framework in the structural decomposition analysis to study the drivers of changes in energy-related CO_2 emissions. The obtained results provide insights for the effective implementation of environmental policy.

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Chapter 1

Introduction

Being the largest and the oldest planned economy in transition, Russia attracted the interest of researchers for a long time[1]. In the past three decades, the country underwent substantial structural and institutional changes. The changes that laid foundations of the modern Russian economy were brought by a series of reforms originating in the period of Perestroika in the 1980s. However, the most prominent set of reforms occurred right after the dissolution of the Soviet Union in the first half of the 1990s. In pursuit of a quick transition to a market economy, the period of the early 1990s was characterized by the rapid dismantling of the command system with implementation of new pricing mechanisms, liberalization of trade, privatization of state property, establishment of new financial, political and national statistics systems (Ivanov, 2009; Shmelev, 2011). The lack of practical experience and the underestimation of the complexity and level of integration of the old Soviet system made the initially planned period of transition of 1-2 years impossible. Consequently, during most of the 90s the Russian economy was in recession. Despite the economic decline, Russia's economy was growing at almost 7% per annum starting in 1999 claiming the 11$^{\text{th}}$ spot in the global GDP ranking by 2008 (Alexeev and Weber, 2013). However, the country continues to struggle from a myriad of issues inherited from the Soviet era. One of the problems is a slow-moving development of the statistical infrastructure. Some elements of the Soviet procedures and guidelines have survived in the Russian system of national statistics to this day. Additionally, in spite of the re-structuring the Russian economy went through, it remains one of the

[1] Leontief (1936); Raiser Schaffer and Schuchhardt (2004); World Bank (2008); Shmelev (2011).

chief producers of raw materials in the world and, therefore, also plays a leading role in generation of CO_2 emissions.

Much of the research literature that examines the structure of the Russian economy via inter-industrial linkages is conducted in the multi-region context, but, to our knowledge, no comprehensive study has been completed on Russia in a single-region setting[2]. The aim of this thesis is to study the production structure of the Russian economy, its embodied carbon emissions, and the drivers of the embodied emission changes over the course of 1980-2013[3]. To accomplish this objective, input-output modeling framework is utilized with data from two national sources.

The first chapter contains a comprehensive sensitivity analysis of input-output multipliers based on Russian data. Input-output multipliers are widely utilized by policy-makers in simple impact analysis or scenario testing. The multipliers are calculated on the basis of a symmetric input-output table. The integral components of the symmetric input-output table are intermediate transactions, final demand, and value added. The construction of such a table is exposed to many potential sources of errors. It has been shown that present in intermediate transactions bias tends to accumulate once multipliers are derived (Roland-Holst, 1989; Dietzenbacher, 2006). In this chapter we empirically check this claim and assess the extent of bias transmission and stability of input-output multipliers to random perturbations that are assumed to be present in raw input-output data. To this end, we employ a Monte Carlo simulation technique. We use data from two Russian sources and, for comparative purpose, utilize German national data and data published by international input-output databases (WIOD and Eora). We find that multipliers derived from all datasets accumulate bias when the simulated sample size is large ($\geq 1,000$). However, in practical terms the size of the bias is so small that it can be disregarded when conducting an economic analysis. In addition, the Russian multiplier estimates exhibit on average greater stability than those derived from German and international sources utilized in the study. We conclude that, even though there have been concerns in the literature surrounding the quality of the Russian statistical data, the derived multipliers perform on the level of comparable multiplier

[2]Sun (1998); Xu and Dietzenbacher (2014); Lan et al. (2016); Wang et al. (2017).

[3]Due to limited data availability we study the structure of the Russian economy in the period of 1980-2006 and the embodied emissions in the period of 1992-2013.

estimates derived from OECD country data and on average remain stable to introduced bias.

The second chapter undertakes a detailed study of the production structure of the Russian economy based on the analysis of sectoral interrelations prior and during the transition period covering 1980-2006. Again, the input-output framework provides an analytically simple and comprehensive approach to measuring the economic impact of individual industries on the entire economy based on cross-checked, reliable data (Miller and Blair, 2009). Within the framework, impacts are studied via calculated input-output multipliers. The multipliers provide a robust way to study the structure and characteristics of the economy during the static time period for which the underlying input-output table is created. The main attractive feature of the input-output framework is the ability to track interlinkages between sectors of the economy. Via the notion of input-output multipliers it is analytically possible to disentangle the effects of an exogenous demand change in one industry on the entire economy. The captured effects quantify how much output (or GDP, employment, carbon emissions) in all sectors of the economy is generated to satisfy the additional amount of final demand in a single sector directly and indirectly through a spiral of additional output created to deliver inputs to production. Thereby, the calculated effects can be ranked by order of magnitude to determine the performance of any sector in relation to other sectors within the economy to subsequently establish the relative importance of each industry. In addition to measuring the magnitude of the effects, the input-output modeling framework also describes their direction. In this study, we compute a variety of multipliers: Type I and Type II output, Type I and Type II GDP, Type I and Type II employment multipliers as well as net output and net value added multipliers. We find that throughout the period under consideration, the production structure of the Russian economy characterized by the strength of inter-industrial linkages remains energy-intensive. However, there is a shift from specialization in manufacturing during the Soviet period towards specialization in production of raw natural resources such as oil and (ferrous and non-ferrous) metals in the latter years. The late specialization is shown to be driven by foreign final demand. Additionally, we find empirical support for growing importance and strengthening of the inter-industrial linkages of service providing sectors over the entire transition period.

The third chapter is dedicated to studying energy-related direct and embodied carbon emissions generated by the Russian economy and their drivers in the period of 1992-2013. To accomplish this objective, we utilize an environmentally extended input-output modeling framework and the structural decomposition analysis technique. The structural decomposition technique gained popularity in environmental research in the 2000s. It is based on index number theory and, therefore, allows to disaggregate a change in an aggregate indicator into a set of pre-defined components (Lan et al., 2016). Analyzing the size and the direction of each component allows to determine which component contributes to changes in emissions. In this study we decompose the change in emission generation into six effects: the emission coefficient effect, the energy mix effect, the energy intensity effect, the (Leontief structure) production technology effect, the final demand structure effect, and the total final demand effect. We divide time period under consideration into four sub-periods 1992-1996, 1996-2000, 2000-2008, and 2008-2013. We find empirical support that when it comes to emission generation, the Russian economy remains significantly receptive to shocks –in particular to demand shocks. In the period 1992-1996 we note a significant drop in emission generation induced mainly by an outflow of final demand. During the boom years 2000-2008, we observe a substantially opposite effect. The susceptibility to demand shocks can be partially explained by approximately 50% of the federal budget being financed through revenues from the sale of oil and gas. The results of this study suggest that the production technology in Russia exhibits significant improvement starting in the early 2000s. However, during the period 2008-2013, the environmental technology showed signs of deterioration for the first time since 1992. Additionally, our results show that in 2013 the economy still predominantly specializes in energy-intensive production.

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Chapter 2

Bias and Stability of Input-Output Multipliers: Evidence from Russian and German data

2.1 Introduction

Input-output data is often employed in economic modeling. Because of uncertainty present in the data, reliability checks are encouraged to establish the accuracy and consistency of the derived estimates. Due to oftentimes underdeveloped statistical infrastructure, and procedures incomparable to international standards, it is particularly important to check the data published by developing countries and economies in transition (OECD, 2006).

The aim of this chapter is to provide a comprehensive sensitivity analysis of the input-output modeling framework to the noise in input variables using methodology derived by Roland-Holst (1989) and Dietzenbacher (2006) for the Russian economy. We assess how the assumed random perturbations in the intermediate transaction and final demand elements of the Russian input-output table affect multiplier estimates. To this end, we set up a Monte Carlo simulation with perturbations originated in the raw input-output data represented by normally distributed, independent, stochastic shocks with zero mean and constant variances. We draw $K = \{10, 20, 50, 100, 1,000, 10,000\}$ random matrices of Leontief multipliers and compute the average values over K simulation runs. To assess bias persistence and multiplier stability, we statistically compare the results with the unperturbed matrices of input-output multipliers.

Moreover, we compare multiplier stability for three different input-output datasets for the Russian economy. The first dataset is published by the Russian Federal State Statistics Service (ROSSTAT). The ROSSTAT input-output tables defined on 22 sectors ($n = 22$) are available for the period of 1998-2003 and follow the Soviet industry and product classifications (ROSSTAT, 2017). The second and the third datasets are published by the Institute of Economic Forecasting (IEF) within the Russian Academy of Sciences. One of the IEF input-output datasets is compliant with the old, Soviet industry and product classifications (OKONh, $n = 25$), while the other follows the new, internationally comparable classification (OKVED, $n = 44$).

The contribution of this chapter is twofold. First, we add to the literature on uncertainty treatment by applying the methodology derived by Roland-Holst (1989) and Dietzenbacher (2006) to detailed input-output data from another OECD country (Germany) and to detailed input-output data from Russia. Second, we provide a comprehensive analysis of uncertainty treatment in input-output multipliers for three Russian datasets and show that the multipliers derived from Russian sources behave in a similar manner to multipliers derived from German sources. Therefore, this sensitivity study may act as a reference for other researchers looking to conduct an input-output analysis for Russia.

To assess robustness, we extend the data coverage to include national input-output data from Germany ($n = 57$) as well as Russian and German data from international input-output databases, i.e. WIOD ($n = 34$) and Eora ($n = 47$). In line with Dietzenbacher (2006), we find that across all datasets the estimated multipliers are positively biased, but the actual size of the bias is minimal and can be detected only in large samples of $K \geq 1,000$. Because the bias is so small, we conclude that the derived input-output multipliers can be treated as unbiased when employed in economic analysis. The absolute size of the bias and the standard deviation in multipliers derived from the Russian national data (ROSSTAT and IEF OKONh) is greater than the bias and standard deviation for Eora and German national data (DESTATIS). However, the coefficient of variation is smaller for Russia. As a consequence, the multipliers derived from the Russian national data exhibit on average greater stability than those derived from the Eora or German data. This result is important, because it shows that the Monte Carlo approach of Dietzenbacher (2006) is valid not only for the Netherlands, but also for Germany, and Russia –despite various institutional and conceptual differences between the countries. To the best of our knowledge, this is the first study that establishes this result for Russian data.

As a further robustness check, we relax distributional assumptions and utilize the theory of norms to measure whether the input-output system is well-conditioned. We follow Wolff (2005) who suggests the use of DESTATIS data as a comparative anchor of a well-conditioned data system. In line with the Monte Carlo results, this suggests that Russian data is well-conditioned and is similar to German data in its ability to absorb random perturbations.

The uncertainty treatment of input-output multipliers has received a wide coverage in the literature[1]. Simonovits (1975) analytically shows that if the derived input-output multipliers are stochastic and overestimate the true (but unknown) values, biases in the estimates are expected to accumulate. While utilizing the Monte Carlo simulation approach, Roland-Holst (1989) empirically tests for the existence of positive bias in multiplier estimates while assuming the underlying data to be stochastic. On the contrary to the analytical formulation, he finds no bias and growing stability in N in the multiplier estimates for sample sizes $N = \{10, 20, 50, 100\}$. Dietzenbacher (2006) extends the framework to include $N = \{1,000, 10,000\}$ and discovers presence of bias and on average greater instability of the multiplier estimates than the stochastic elements they are based on. His country coverage includes data from 10 OECD countries with special attention in robustness checks (i.e., sectoral aggregation) dedicated to the input-output data from the Netherlands. Even though a bias is found, the size of the bias is small and can be disregarded.

The structure of the chapter is as follows. Section 2.2 provides a brief literature review on stochastic analysis within the input-output framework. Next, Section 2.3

[1] Quandt (1958, 1959); Simonovits (1975); West (1986); Jackson and West (1989); Roland-Holst (1989); Dietzenbacher (2006); ten Raa (2017).

specifies the Russian input-output data construction. In Section 2.4 we describe in detail the Monte Carlo simulation set up and how the theory of norms helps in detection of condition problems. In Section 2.5 we describe various specifications of the Monte Carlo experiment and an extended discussion of the results. Section 2.6 summarizes the work.

2.2 Literature Review

The input-output methodology was originally developed by Leontief (1936). Subsequently the basic concepts introduced by Leontief became major components across a wide range of branches of economic analysis (Baumol, 2000). But it is not until an extensive work over next decades by Stone (1961) that the input-output framework received recognition and was integrated within the system of national accounts. According to Stone, the input-output framework is unique in the sense that it provides an opportunity to check whether an economic theory can be supported by statistics. Since being first implemented, over ninety countries, including Russia, incorporate input-output tables in their system of national accounts. A detailed historic coverage of the development of input-output tables can be obtained in the 'Handbook on Supply, Use and Input-Output Tables with Extensions and Applications' (UN, 2018).

2.2.1 Data Uncertainty Treatment

Not long after input-output tables became an inherent feature of the national accounts and the input-output multipliers started to be a widely used tool of economic modeling, researchers started to acknowledge their stochastic nature (Quandt, 1958, 1959). Nevertheless, multiplier matrices are widely used to describe production processes in input-output analysis as well as in computable general equilibrium (CGE) models.

One of the main components of the input-output table is a transactions matrix that captures inter-industrial flows of inputs to production. This transactions matrix is a basis in calculation of the matrix of technical coefficients, $\mathbf{A}$, that represents a mix of inputs required to produce a unit of output, and subsequently the matrix of input-output multipliers, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$. Because the matrix of technical coefficients **A** feeds into the desired multipliers' matrix **L**, it is understandable why many researchers chose **A** as a starting point in data uncertainty treatment[2]. An extensive literature review on uncertainty propagation from the matrix **A** into the elements of the matrix **L** has been completed in Jackson and West (1989).

There exists, however, a different research direction that acknowledges the fundamentality of the transactions matrix in construction of the matrices **A** and **L**. This research literature takes on a so-called "practitioner's" approach and treats the transactions table as stochastic. Among the practitioners of such approach are Gerking (1976b), Gerking (1979), Roland-Holst (1989), Dietzenbacher (2006).

It is widely acknowledged that the construction of a transactions table is exposed to much uncertainty (Gerking, 1976a; Miller and Blair, 2009). The sources of such errors can be various. For example, ESA (1995) and SNA (1993) recommend utilizing the rectangular supply and use tables in the construction of a symmetric input-output table. The transformation of the rectangular tables to a balanced square form requires undertaking additional assumptions on the allocation of products (i.e. industry vs product technology), conversion of prices, and other balancing adjustments to represent economy's general equilibrium. Moreover, the data is survey-based. The processes of collecting, processing and organizing the data take up to five years on average (UN, 2018). Therefore, so-called base year input-output tables are released with a delay. It means that the technology represented in the matrix **A** is outdated by the time it reaches an analyst. Moreover, in order to fill in the gaps between the base years, the statistical agencies derive annual input-output tables with the aid of deterministic scaling algorithms, such as the bi-proportional RAS technique or maximum entropy methods (Bacharach, 1970; Miller and Blair, 2009). Not only that the use of such algorithms adds to the stochastic nature of the data, the estimations in annual tables are based on the technology represented in the base year, which in itself can be argued to be unrealistic. Other problems such as aggregation perturbations may also arise (Gerking, 1976a,b, 1979).

There exist several approaches in the literature on uncertainty treatment in an

[2]Simonovits (1975); Brown and Giarratani (1979); Hanseman and Gustafson (1981); Lahiri (1983); West (1986); Lenzen (2001).

input-output system. These are deterministic error analysis, econometric and statistical approach, random error analysis or probabilistic approach, full probability density distribution approach, Monte Carlo analysis, Bayesian approach, and other methods. A detailed literature review on all of the methods has been completed in ten Raa (2017). The full probability density distribution, Monte Carlo, and Bayesian approaches often adopt assumptions of independence, normality, and bi-proportional stochasticity of the elements derived in the literature under the probabilistic approach (Quandt, 1958; Simonovits, 1975; Lahiri, 1983). This chapter also relies on these assumptions and utilizes the Monte Carlo approach.

2.2.2 Monte Carlo simulation approach

Bullard and Sebald (1988) first introduced the Monte Carlo simulation approach to study uncertainty propagation through the input-output system. Simonovits (1975) showed analytically that if the technical coefficients a_{ij} of matrix $\mathbf{A}$ are independent random variables, the derived multipliers are positively biased, i.e. $\mathbb{E}(\mathbf{L}) = \mathbb{E}[(\mathbf{I} - \mathbf{A})^{-\mathbf{1}}] > [\mathbf{I} - \mathbb{E}(\mathbf{A})]^{-1} = (\mathbf{I} - \mathbf{A}^0)^{-1} = \mathbf{L}^0$. Relaxing assumption of independence to a class of dependent coefficients, Lahiri (1983) shows that the described relationship still holds when the bi-proportional stochasticity in input-output coefficients is preserved. Later, Flam and Thorlund-Petersen (1985) generalized the relationship for moment-associated random variables and proved that the estimator of Leontief inverse is overestimated if input coefficients are assumed to be non-negative moment-associated random variables.

Most of the literature that studies the uncertainty propagation presumes the origin to be in the matrix $\mathbf{A}$ ("classical" approach). Among the users of the "practitioner's" approach, Roland-Holst (1989) is the first to apply the Monte Carlo analysis on perturbed transaction flows and final demand values to test the existence of positive bias in multipliers, as analytically stated by Simonovits (1975).

Roland-Holst (1989) draws perturbed intermediate transaction and final demand elements from the normal distribution based on Monte Carlo simulation runs ($N = \{10, 20, 50, 100\}$). The errors are assumed to be independent, which is a strong but standard in the literature assumption. It can be argued that the shocks to elements are not independent to one another. Given a small amount of observed, survey-based input-output tables, it is not feasible to estimate the variance-covariance relationships of the error terms. Therefore, we approximate the unknown relationships assuming random and independent errors in the intermediate transaction and final demand elements. Perhaps in the future, when the collection of national accounting data is automatized and a sufficient amount of surveyed input-output tables is available, future researchers will be able to estimate the variance-covariance relationships, so we do not have to rely on the assumption of random, independent error terms.

After obtaining the perturbed intermediate transactions and final demand elements, Roland-Holst (1989) then computes the perturbed matrices of multipliers $\mathbf{L}$ and finds the average of each element l_{ij} for each of the runs. Finally, he compares the average of the perturbed multipliers with the multipliers derived from observed transactions and final demand elements. The extent of assumed variation in perturbed intermediate transaction and final demand elements is assumed to be of $5\%, 10\%$ and 20% of the observed values. The empirical finding of Roland-Holst (1989) contradicts the analytical proof of present positive bias by Simonovits (1975). Roland-Holst (1989) shows that for sample sizes $N = \{10, 20, 50, 100\}$, the disaggregated multiplier estimates are unbiased, implying that if the intermediate transaction and final demand elements contain well-behaved, i.e. normal, errors with variation of no greater than 20%, the multiplier estimates will be centered on their true distribution. Additionally, he shows that as N increases, the estimated multipliers are more stable than their counterparts derived from the observed transaction elements.

Dietzenbacher (2006) extends the framework developed by Roland-Holst (1989) to include $N = \{1,000, 10,000\}$. He finds that there is no controversy between the "classical" and "practitioner's" approaches and that both of them arrive at the same result of uniformly positively biased multiplier estimates, when the transactions are unbiased and independently, normally distributed. Dietzenbacher (2006) concludes that even though the individual biases are present and statistically significant, in practice when conducting typical economic input-output analysis these biases can be ignored due to their negligible size.

This chapter builds on the framework of Roland-Holst (1989) and Dietzenbacher (2006) utilizing Russian data published by the official statistical source and the Russian Academy of Sciences. We test datasets published under different industry and product classification methods: material (developed for command economy) and modern (developed for market economy).

2.3 Data

2.3.1 Transition period

According to Voskoboynikov (2012), the key obstacle in conducting any Russian economic analysis is the quality of the national data. The UN SNA standards were introduced in Russia in the early 1990s, in an attempt to substitute for the standards under the Soviet national income accounting called the Material Product System (MPS) (Supreme Council of Russian Federation, 1992). The process of transition proved to be slow-moving and even in the 2010s some rudiments of the MPS have survived in the Russian system of national statistics. The co-existence of the MPS and SNA standards creates conceptual inconsistencies between different blocks of the Russian statistical system (Ivanov, 2009). According to Voskoboynikov (2012), the Russian statistics have been known to inflate certain figures, such as GDP. Ivanov (2009) claims that the overstating occurred not for reasons of differences between the two methodologies but due to more fundamental issues within the MPS.

To name some of these issues, the MPS amplified the industrial production and exhibited disregard to most of the market services. Arguably, the MPS principles for measuring national output are rather similar to the SNA, except that non-material services were excluded from the MPS. The MPS concentrated on measuring output and intermediate consumption in industries that produce material goods. As a result, there was an exaggerated focus on manufacturing and agricultural sectors of the economy. Though there was an attempt to measure services within this classification, they carried an imprint of the centrally planned economy (Ivanov, 2009) and often were not representative of real life (Masakova, 2006). There were no adequate attempts made to measure underground economy. However, this problem is not only inherent to Russia. Generally, it is difficult to properly define and estimate the size and development of the shadow economy (Schneider and Williams, 2013). Additionally, the MPS measured the services provided by households for their own consumption at cost, rather than at the market rent equivalent. The system had poorly developed pricing mechanisms. A considerable problem was that the consumer price indices (CPIs) were not consistent with international standards. These shortcomings resulted in upward inflated numbers. Various productivity measures (e.g. labor, capital, multifactor) also remained in a nascent states. The definition of what constitutes financial and other non-produced assets and their valuation differed from the SNA recommendations. Overall, the lack of experience in conducting household and labor surveys and of preparing price statistics especially in periods characterized by high inflation, mass reallocations of capital and labor force led to inconsistencies in the official data over the years of transition (Ivanov, 2009).

The industry and product classifications were changed four times in the period of 1990-2009 (ROSSTAT, 2017). In modern Russia the Russian Federal State Statistics Service (ROSSTAT) acts as a statistical infrastructure that collects, processes and publishes various economy-wide statistics including input-output tables. The latest available base input-output table dates back to 1995[3]. All published annual input-output tables (1998-2003) are derived from the base table. The annual input-output tables follow the MPS industrial classification (OKONKh, 'Otraslevaya Klassifikaciya Narodnogo Khozyajstva') and All-Russian Product Classification (OKP, 'Obscherossiiskyi klassifikator produkcii'). In 2003 the OKONh industrial classification was replaced by a new industrial classification (OKVED, 'Obschcherossiiskyi Klassifikator Vidov Ekonomicheskoi Deyatel'nosti'), which is consistent up to four digits with the Statistical Classification of Economic Activities in the European Community (NACE Rev.1), but still follows the OKP on the product level. Such inconsistency made the derivation of the annual symmetric input-output tables impossible, keeping the base year of 1995. Therefore, since 2004 there is a break in input-output time series published by the ROSSTAT. The work on development of the new base input-output table for 2011 started in 2012. It is based on the OKVED 2007 (or NACE 1.1) and the new OKPD ('Produkciya po vidam ekonomicheskoi deyatel'nosti') product classification, which is

[3]Please note that at the time of writing of this chapter this was the case. The new base input-output table is published in July 2018: www.gks.ru.

harmonized with the European counterpart the Classification of Product by Activity (CPA). Such consistency with international sources makes the side-by-side analysis with other European countries possible. Following the creation of the 2011 base input-output table, the new base tables are expected to be released every five years.

2.3.2 Data description

As mentioned in the previous subsection, the OKONh classification differs from its European counterpart OKVED/NACE Rev.1. Consequently, there are significant differences in the input-output data following either classification.

The absence of the input-output tables consistent with international standards makes it challenging to create a reliable analytical work. Moreover, the limited size of time series of available data from the ROSSTAT exacerbates the restrictive nature. Due to such culprits, several research institutes attempted to create their own systems of input-output tables. One such development is based on work of the Institute of Economic Forecasting (IEF) (a branch of the Russian Academy of Sciences (RAS)). The institute has developed input-output tables for the period of 1980-2006 consistent with the OKONh/OKP classification and for the period of 1980-2013 consistent with the OKVED 2007/OKPD classification (IEF, `macroforecast.ru`). In fulfillment of the data requirements and for balancing of the tables, the institute obtains information from the ROSSTAT and partially through own-effort survey methods with subsequent utilization of the in-house algorithm. It is an attractive source of data as it offers nationally generated input-output time series by an internationally reputable statistical source.

According to the NACE classification, the energy sector is represented by the 'Mining and quarrying' and 'Coke, refined petroleum and nuclear fuel' sectors (Eurostat, 2002). The 'Mining and quarrying' sector includes extraction of coal, lignite, peat, crude petroleum, natural gas, uranium and thorium ores, as well as ferrous and non-ferrous ores, stone, chalk, clay, sand, gravel, pit, chemical and fertilizer minerals, salt. Refining of petroleum products enters the classification under the 'Coke, refined petroleum and nuclear fuel' sector.

On the other hand, in the OKONh classification the energy sector separates into 'Oil and gas production', 'Coal', and 'Oil shales and peat' sectors (ROSSTAT, 2017). The IEF institute subdivides in their dataset following the OKONh classification the 'Oil and gas production' into additional three sub-sectors: 'Products of oil excavation', 'Products of oil processing' and 'Products of gas production' (IEF, 2017). The 'Products of oil excavation' include excavation of oil and associated petroleum gas. The 'Products of oil processing" include refining of oil and production of oil products. The 'Products of gas production' include excavation and refining of natural gas and associated petroleum gas and production of helium. Under the OKONh the coke production is represented as a part of the 'Coal' sector and nuclear fuel under the 'Electric and heat-generating energy' sector. All extraction and processing activities of ferrous and non-ferrous ores, chemical minerals and petrochemical compounds are recorded under specifically designated sectors of the economy. Having additional disaggregation dimensions for the energy-producing industry makes the data developed by the IEF in the OKONh classification more attractive than the official ROSSTAT data.

We will use three datasets from two Russian sources in this chapter – ROSSTAT input-output tables for 1998-2003 ($n = 22$), and IEF input-output tables for 1998-2003 following OKONh ($n = 25$) and OKVED ($n = 44$) classifications. The choice of years is determined by data availability. The only official national data is published by the ROSSTAT. The latest input-output table dates back to 2003 and follows the Soviet OKONh industry and OKP product classifications. Even though the ROSSTAT published the supply and use tables for 2004-2006, from which the new input-output tables theoretically could be derived, it is not recommended due to conflicting industry and product classifications during this period. The derived input-output tables would not be comparable to either previous ROSSTAT OKONh or to IEF OKONh and OKVED or any other input-output tables. Appendix A provides full description of industries under the OKONh and OKVED classifications.

To cross-check the results of the Monte Carlo simulation based on the Russian data, we also use input-output data from other internationally reputable sources. One of such sources is the research project created solely with the purpose of developing global multi-regional input-output tables – the World Input-Output Database (WIOD), created by the University of Groningen, Netherlands (WIOD, www.wiod.org). The database provides input-output tables for Russia based on 35 industries and 59 types of products in the NACE Rev. 1.1/CPA classification and covers the desired period of 1998-2003. A comprehensive overview of the construction of the WIOD is available in Dietzenbacher et al. (2013). Another source is the EORA MRIO database ((EORA MRIO, www.worldmrio.com). It is an open-access statistical data source developed by the research group at the University of Sydney. The database specializes in the provision of detailed trade, emissions, and energy use accounts. The full information on the construction, sensitivity analyses, and other useful information about the database can be found in Lenzen et al. (2013). This database also publishes input-output tables for Russia for years 1998-2003 and covers 47 sectors of the economy according to the ISIC Rev.3 (≡NACE Rev. 1)/CPA classification. Even though the Russian and international data sources provide their data in different monetary units (Rubles vs US Dollars), it does not affect the results of our sensitivity tests as the derived input-output multipliers are unitless measures (Miller and Blair, 2009). The Russian input-output tables (ROSSTAT OKONh, IEF OKONh, and IEF OKVED) are built in such a way that the imported and domestic transactions are produced using similar technology, i.e. the assumption of competitive imports.

In addition, we conduct tests utilizing German data. The quality of German official data is considered exemplary in the research community (Wolff, 2005). We use the input-output tables for Germany published by the German federal statistical agency ($n = 57$, DESTATIS, www.destatis.de) and by the WIOD for 1998-2003. If Russian data withholds a comparison with German data in terms of being able to produce unbiased and stable multipliers despite of assumed uncertainty of given magnitude in raw values, it could suggest a level of trustworthiness of the economic indicators derived from the Russian national data sources.

All of the data in this study is in current prices. Miller and Blair (2009) suggests the use of data in current prices when analyzing stability of coefficients/multipliers for reasons that if prices of inputs to production of some output j increase over a given period, the price of j will most certainly also increase. So, there will be a compensating movement in the numerators and denominators of the technical coefficients a_{ij}.

Therefore, coefficients and, as a consequence, multipliers using current prices are likely to exhibit more stability.

2.4 Methodology

The input-output tables depict economic activity in terms of purchases and sales between industries and final consumers with an aim of fulfilling intermediate and/or final demand (Miller and Blair, 2009). In its basic form the input-output framework consists of a system of linear equations that describe the sales and purchases of products throughout the economy (Miller and Blair, 2009). Each argument of these linear equations is an entry in the input-output table. The main feature of the input-output table is the interindustry transactions table ($\mathbf{Z}$). The rows ($\mathbf{Z}_i$) of this table represent the distribution of a sector's output throughout the economy. The columns ($\mathbf{Z}_j$) describe the input requirements in order to produce a unit of output by a given sector. The matrix $\mathbf{Z}$ represents endogenous agents in the model. Because the Russian input-output table assumes competitive imports, the table $\mathbf{Z}$ includes domestic and imported intermediate inputs. We will cover the concept of competitive imports in the next chapter. Another important section of the input-output table is the final demand ($\mathbf{Y}$) which is a record of purchases of a sector's output by final market. The final demand category, represented by households, government, capital requirements, and foreign demand, acts as an exogenous part in the system.

Due to the square structure of the input-output table, which can be represented as a set of n linear equations with n unknowns, the system can be written in matrix form (Leontief, 1936; Miller and Blair, 2009): $\sum_{\mathbf{j}} \mathbf{Z} + \sum_{\mathbf{j}} \mathbf{Y} = \mathbf{X}$, where $\mathbf{Z} = [z_{ij}]$ is an $n \times n$ matrix of intermediate inputs, $\mathbf{Y} = [y_{ij}]$ is an $n \times m$ matrix of final demand, and $\mathbf{X} = [x_i]$ is a $n \times 1$ vector of gross output. An input-output model is a static general equilibrium model where total produced output by a sector (row total) equals total input requirements by the same sector (column total). Therefore, $x_i = x_j$.

Since an input-output table is a snapshot of an economy's production within a given year, it also incorporates within itself a record of the production technology. The production technology within the input-output framework is defined as the amount of inputs needed from each sector i to produce a unit of output by a sector j, or $a_{ij} = z_{ij}/x_j$. This $n \times n$ matrix $\mathbf{A}$ of direct input (technical) coefficients is one of the key features of the input-output framework. Because the proportion of inputs to output, as depicted in the matrix $\mathbf{A}$, remains fixed, one of the main assumptions of the framework is that the production technology remains unchanged within specified time period. This period, as we mentioned in Section 2.2, usually is five years, i.e. the length of time between adjacent publications of input-output base tables. Normally the annual tables assume the base year's technology (Miller and Blair, 2009). Moreover, this technology (the ratio of inputs from each sector to produced unit of output) is assumed to have constant returns to scale in production. Meaning once the ratio of inputs is determined, it does not change. And, if a sector j would decide to double its production, it could achieve this goal by doubling the inputs i according to pre-determined proportions in the matrix $\mathbf{A}$. Hence, in contrast to classical production functions, no substitution of one input for another in the production process is possible, hence production function is Leontief.

After defining the matrix $\mathbf{A}$, the input-output system can be re-written as: $\mathbf{AX} + \mathbf{Y} = \mathbf{X}$, and, subsequently, as $(\mathbf{I} - \mathbf{A})\mathbf{X} = \mathbf{Y}$, where $\mathbf{I}$ is an $n \times n$ identity matrix. The matrix $(\mathbf{I} - \mathbf{A})$ is called a technology matrix within the input-output methodology framework. When $(\mathbf{I} - \mathbf{A})$ is square and non-singular, i.e. no eigenvalue is zero, the inverse exists and the Leontief identity can be derived: $(\mathbf{I} - \mathbf{A})^{\mathbf{-1}}\mathbf{Y} = \mathbf{X}$, where $(\mathbf{I} - \mathbf{A})^{\mathbf{-1}} = \mathbf{L} = [l_{ij}]$ is known as the Leontief inverse, or the total requirements matrix. A detailed coverage of conditions necessary for existence of the Leontief inverse matrix $\mathbf{L}$ can be found in Waugh (1950).

The Leontief identity equation is the centerpiece of the demand-driven input-output framework. It allows to uncover information on inter-industry relations which characterize the structure of the economy given a particular state of technology. A unique solution given by the Leontief identity equation discloses how much output is generated (directly and indirectly as mathematically represented within the power series of the Leontief inverse) throughout the economy given a certain level of final demand. The Leontief inverse $\mathbf{L}$ is also called a matrix of output multipliers. It describes how much output is generated directly and indirectly throughout the economy to satisfy an additional unit of final demand. In other words, a sector j requires a set of inputs from all industries including itself. However, these industries need inputs of their own. The first round of inputs is the initial effect or $\mathbf{I}$ within the Leontief inverse, $(\mathbf{I}-\mathbf{A})^{-\mathbf{1}} = \mathbf{I}+\mathbf{A}+\mathbf{A}^2+\mathbf{A}^3+\ldots$, the second round or the amount $\mathbf{A}$ represents additional direct output that is induced within the economy, and the subsequent rounds of induced production, $\mathbf{A}^2$, $\mathbf{A}^3$, ... are the indirect effects. Hence, the notion of a multiplier.

As was discussed in Section 2.3, since the input-output models are based on empirical data, a leeway for parametric uncertainty through various possible channels is generated, i.e. measurement errors when constructing the supply and use tables, further corrections that are applied when balancing the input-output table, understated changes in production technology, etc. (Bullard and Sebald, 1988). The aim of this chapter is to study the uncertainty propagation originated in the transactions matrix $\mathbf{Z}$ and the matrix of final demand $\mathbf{Y}$ to the matrix of Leontief multipliers $\mathbf{L}$. If $\mathbf{L}$ is stochastic and each element l_{ij} overestimates its true (but unknown) value l^0_{ij}, i.e. $E(l_{ij}) > l^0_{ij}$, biases are expected to accumulate, as was shown analytically by Simonovits (1975).

The set up of the Monte Carlo simulation experiment is as follows. The starting point of the experiment is an observed matrix $\mathbf{Z^0}$ and vector $\mathbf{y^0} = \sum_i \mathbf{Y^0}$. If k is the sample size, it is assumed that $\mathbf{Z}$ and $\mathbf{y}$ are randomized around their observed values. That is, $\forall\ i,j = 1,\ldots,n$, and $k = 1,\ldots,K$,

$$z^k_{ij} = z^0_{ij} + \zeta^k_{ij} \text{ and } y^k_i = y^0_i + \upsilon^k_i \tag{2.1}$$

with

$$\zeta^j_{ij} \sim N(0;(\rho^0 z^0_{ij})^2) \text{ and } \upsilon^k_i \sim N(0;(\rho^0 y^0_i)^2). \tag{2.2}$$

All randomizations are independent of each other. The standard deviations of the perturbations are chosen as a percentage of the observed values, $\rho^0 = 0.1$ (in line with Roland-Holst (1989)). It was shown in the literature that such assumption is reasonable. Bullard and Sebald (1977) estimate error bounds of the Leontief inverse using the norm theory, but they conclude that the perturbation techniques (such as Monte Carlo) will yield tighter bounds. They state that this result holds even for the worst case scenarios of simultaneous increase or decrease of all coefficients in **A**. Based on Bullard and Sebald (1977, 1988), it became a convention to take standard errors in the elements to be 5-25%. For example, Roland-Holst (1989) assumes the variation to be 5%, 10%, and 20% in transaction and final demand elements.

Once we generate the perturbed elements z_{ij}^k and y_i^k, we calculate the gross output $x_i^k = \sum_j z_{ij}^k + y_i^k$, then the technical coefficients $a_{ij}^k = z_{ij}^k / x_j^k$, and finally the Leontief multipliers $\mathbf{L}^k = (\mathbf{I} - \mathbf{A}^k)^{-1}$. The hypothesis to be tested is that the multipliers are unbiased, $H_0 : E(l_{ij}^k) = l_{ij}^0$. To test the hypothesis, the t-statistics are calculated:

$$t_{ij} = \frac{\bar{l}_{ij} - l_{ij}^0}{s_{ij}/\sqrt{K}}, \tag{2.3}$$

where $\bar{l}_{ij} = \sum_{k=1}^K l_{ij}^k / K$ is the sample average and $s_{ij}^2 = \sum_{k=1}^K (l_{ij}^k - \bar{l}_{ij})^2/(K-1)$ is the sample variance.

In order to analyze the stability of the multipliers, the following ratios are calculated:

$$\rho_{ij} = s_{ij}/(l_{ij}^0 - \Delta_{ij}), \tag{2.4}$$

where Δ_{ij} denotes the Kronecker delta (i.e., $\Delta_{ij} = 1$ if $i = j$ and $\Delta_{ij} = 0$ otherwise). The Kronecker delta is subtracted from the elements of the matrix **L** to take out the initial effect of increased final demand on inducement of production, or $\mathbf{L}^* = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \ldots - \mathbf{I}$. However, Dietzenbacher (2006) shows that even if the Kronecker delta is not incorporated into the stability variable (following Roland-Holst (1989)), the results change only marginally and do not affect the conclusions of the study. We will cover both scenarios in this chapter. The idea behind calculating the stability variable ρ_{ij} is to check whether the multipliers are more stable ($\rho_{ij} < \rho^0 = 0.1$) or less stable ($\rho_{ij} > \rho^0 = 0.1$) with the presence of stochastic elements in the input-output table.

In the constructed hypothesis test to determine stability the null hypothesis is $H_0 : \rho_{ij} = \rho^0 = 0.1$ and the test-statistic is:

$$\chi_{ij}^2 = \frac{(K-1)\rho_{ij}^2}{(\rho^0)^2}. \tag{2.5}$$

Following Dietzenbacher (2006), we utilize the sample sizes of $K = \{10, 20, 50, 100, 1,000, 10,000\}$ on input-output data from official and international sources for Russia and Germany over 1998-2003.

However, if a researcher wishes to refrain from imposing an additional assumption on the distribution of perturbations in the data, Wolff (2005) suggests to use norm analysis to test the robustness of the Leontief inverse elements to random perturbations. Bullard and Sebald (1977) and Wolff (2005) note that utilization of norms will help detect any condition problems without resorting to additional assumptions on the distribution of errors or changes in the matrix elements.

Let us abbreviate the Leontief matrix $(\mathbf{I} - \mathbf{A})$ as $\mathbf{B}$, then if the true Leontief matrix equals to $(\mathbf{B} + \epsilon\mathbf{F})$ rather than $\mathbf{B}$ and the true vector of final demand equals to $(\mathbf{y} + \epsilon\mathbf{f})$ rather than $\mathbf{y}$, where $\mathbf{F}$ is a real-valued $n \times n$ matrix, $\mathbf{f}$ is a real-valued $n \times 1$ vector, and ϵ is a real-valued scalar parameter that reflects the size of the deviation of the true matrix from $\mathbf{B}$ and $\mathbf{y}$. The term $\epsilon\mathbf{F}$ can capture possible measurement errors carried over from the transactions matrix $\mathbf{Z}$ or even unforeseen technology change (Wolff, 2005). And, the term $\epsilon\mathbf{f}$ captures the uncertainty in final demand. The Leontief identity equation becomes:

$$(\mathbf{B} + \epsilon\mathbf{F})\mathbf{x}(\epsilon) = \mathbf{y} + \epsilon\mathbf{f}, \tag{2.6}$$

where, as before, $\mathbf{x}$ is a $n \times 1$ vector of gross output and $\mathbf{y}$ is a $n \times 1$ vector of final demand.

The vector $\mathbf{x}(\epsilon)$ is differentiable for small ϵ[4]. Therefore, differentiating both sides of equation 2.6 with respect to ϵ yields $\mathbf{Fx}(\epsilon) + (\mathbf{B} + \epsilon\mathbf{F})\mathbf{x}'(\epsilon) = \mathbf{f}$ and hence $\mathbf{x}'(0) = \mathbf{B}^{-1}(\mathbf{f} - \mathbf{Fx})$.

The vector $\mathbf{x}(\epsilon)$ can be expanded into a Taylor series around $\mathbf{x}$. In particular, if $R(\epsilon^2)$ stands for the second-order, then $\mathbf{x}(\epsilon) = \mathbf{x} + \epsilon\mathbf{x}'(0) + R(\epsilon^2)$. Substituting for $\mathbf{x}'(0)$ and re-arranging gives:

$$\mathbf{x}(\epsilon) = \mathbf{x} + \epsilon\mathbf{B^{-1}}(\mathbf{f} - \mathbf{Fx}) + R(\epsilon^2) \iff \mathbf{x}(\epsilon) - \mathbf{x} = \epsilon\mathbf{B^{-1}}(\mathbf{f} - \mathbf{Fx}) + R(\epsilon^2). \tag{2.7}$$

[4]The Leontief matrix distorted with $\epsilon\mathbf{F}$ becomes the true Leontief matrix once $\epsilon = 0$, so that equation 2.6 has a unique solution $\mathbf{x} = \mathbf{x}(0)$. For this result to hold, non-singularity of $\mathbf{B}$ is assumed.

A consistent distance measure for $\mathbf{B}$ is given by the Euclidean norm $\|\mathbf{B}\|_2$ of $\mathbf{B}$ which is defined as the positive square root of the maximum eigenvalue of $\mathbf{B^TB}$, where $\mathbf{B^T}$ indicates the transpose of $\mathbf{B}$ (Golub and van Loan, 2013). In the case of square matrices, these norms possess the sub-multiplicative property[5] and will thus satisfy the inequality $\|\epsilon\mathbf{B^{-1}}(\mathbf{f}-\mathbf{Fx})\|_2 \leq |\epsilon|\|\mathbf{B}^{-1}\|_2\{\|\mathbf{f}\|_2 + \|\mathbf{F}\|_2\|\mathbf{x}\|_2\}$. From equation 2.7 we can obtain an upper bound for the relative error in an input-output projection of $\mathbf{x}$ from the perturbed matrix $\mathbf{B}$[6]:

$$\frac{\|\mathbf{x}(\epsilon)-\mathbf{x}\|_2}{\|\mathbf{x}\|_2} \leq |\epsilon|\|\mathbf{B}^{-1}\|_2\left(\frac{\|\mathbf{f}\|_2}{\|\mathbf{x}\|_2} + \|\mathbf{F}\|_2\right) + R(\epsilon^2) = \|\mathbf{B}\|_2\|\mathbf{B}^{-1}\|_2\left(|\epsilon|\frac{\|\mathbf{F}\|_2}{\|\mathbf{B}\|_2} + |\epsilon|\frac{\|\mathbf{f}\|_2}{\|\mathbf{y}\|_2}\right)$$

$$+R(\epsilon^2) = \kappa(\mathbf{B})(\rho_B + \rho_y) + R(\epsilon^2) \tag{2.8}$$

where $\kappa(\mathbf{B}) = \|\mathbf{B}\|_2\|\mathbf{B}^{-1}\|_2$ is the condition number for matrix $\mathbf{B}$, $\rho_B = |\epsilon|\frac{\|\mathbf{F}\|_2}{\|\mathbf{B}\|_2}$ and $\rho_y = |\epsilon|\frac{\|\mathbf{f}\|_2}{\|\mathbf{y}\|_2}$ are the relative errors in $\mathbf{B}$ and $\mathbf{y}$.

The relative error in $\mathbf{x}$ can be $\kappa(\mathbf{B})$ times the relative error in $\mathbf{B}$ and $\mathbf{y}$. So, the condition number represents the sensitivity of the input-output system equation $\mathbf{Bx} = \mathbf{y} \iff (\mathbf{I}-\mathbf{A})\mathbf{x} = \mathbf{y}$. Because the condition number is based on the symmetric and strictly positive definite matrix $\mathbf{B^TB}$, its eigenvalues λ_i are positive real numbers. Therefore, the eigenvalues can be arranged in the following manner $0 < \lambda_1 \leq \lambda_2 \leq \ldots \leq \lambda_n$. This inequality sequence will also be true for their corresponding positive roots σ_i, the so-called singular values of $\mathbf{B}$.

As the maximum eigenvalue of $(\mathbf{B}^{-1})^T\mathbf{B}^{-1}$ always equals the reciprocal of the smallest eigenvalue of $\mathbf{B^TB}$, it can be shown that $\kappa(\mathbf{B}) = \sigma_n(\mathbf{B})/\sigma_1(\mathbf{B}) \geq 1$. Whenever $\kappa(\mathbf{B})$ is large, the matrix $\mathbf{B}$ is not stable. Consequently, the inverse ratio $\tau(\mathbf{B}) = 1/k(\mathbf{B}) = \sigma_1(\mathbf{B})/\sigma_n(\mathbf{B})$ is close to zero. Given the fact $0 < \sigma_1 \leq \sigma_n$, the inverse ratio $\tau(\mathbf{B}) \in (0, 1]$ which allows for easier comparative application. The condition number $\kappa(\mathbf{B})$ and its inverse $\tau(\mathbf{B})$, as can be seen in equation 2.8, do not rely on the distribution of unknown $\mathbf{F}$ and $\mathbf{f}$, which liberates the analysis from distributional assumptions. Moreover, the

[5]In addition to the non-negativity property $\|\mathbf{B}\| \geq 0$ for $\mathbf{B} \in R^n$, $\|\mathbf{B}\| = 0$ iff $\mathbf{B} = 0$, the positive scalar multiplicativity property $\|\alpha\mathbf{B}\| = |\alpha|\|\mathbf{B}\|$ for any $\alpha \in R$ and $\mathbf{B} \in R^n$, and the triangle inequality property $\|\mathbf{B}+\mathbf{M}\| \leq \|\mathbf{B}\| + \|\mathbf{M}\|$ for any $\mathbf{B}, \mathbf{M} \in R^n$.

[6]Keeping in mind that $\|\mathbf{y}\|_2 \leq \|\mathbf{B}\|_2\|\mathbf{x}\|_2$.

results of Wolff (2005) can serve as an orienteer as to what range of values could be considered stable. Wolff (2005) applies the norm analysis to German data. He suggests to use the results of $\tau = 0.46$ for the size 12 and $\tau = 0.19$ for the size 58 of industry aggregation level as robustness benchmarks.

2.5 Results and discussion

The estimated results of Dietzenbacher (2006) show that the average bias of the multiplier estimates becomes positive as the sample size K increases, but remains very small. This result removes the discontent that occurred in the literature between empirical studies (Roland-Holst, 1989) and mathematical predictions (Simonovits, 1975). As for stability estimates, the average uncertainty in derived multipliers for most of the countries in the sample was empirically shown to be slightly larger than assumed uncertainty in raw data. This indicates that the elements of the multiplier matrix are on average less stable than the stochastic elements in the input-output table. Although a considerable part of the bias gets removed by the standard deviation.

We conduct simulation using two data sources of Russian national origin (i.e., ROSSTAT and IEF) and two internationally accredited data sources (i.e., WIOD and Eora) for the years 1998-2003. The IEF offers time series of input-output tables in both OKONh and OKVED/NACE Rev.1 industry classifications. The WIOD and Eora publish input-output data in NACE Rev.1 (≡OKVED) classification. As in Dietzenbacher (2006) we utilize the sample sizes of $K = \{10, 20, 50, 100, 1,000, 10,000\}$.

Tables 2.1, 2.2, and 2.3 provide summaries of the results for the hypothesis test on whether the multipliers on average are unbiased. Table 2.1 represents the results based on the data from the ROSSTAT and IEF datasets that follow OKONh classification. Table 2.2 portrays the results based on the IEF data with OKVED classification. For reasons that will be described later we give two representations of the IEF OKVED data that include and exclude the pharmaceutical production sector. Table 2.3 summarizes the results based on the WIOD and Eora data.

The first panel of the tables records an average bias ($\bar{b} = \sum_{i=1}^{n} \sum_{j=1}^{n} (\bar{l}_{ij} - l_{ij}^0)/n^2$) and its standard deviation ($s_b = \sqrt{\sum_i \sum_j (\bar{b}_{ij} - \bar{b})^2/(n^2 - 1)}$). As can be seen, the biases are positive across all years with relative large standard deviations. The standard deviations are especially large for small sample sizes (< 30) but remain large even when the sample size increases. The multipliers estimated from the Eora data return the least average bias across all years relative to all other datasets. The IEF OKVED with pharmaceutical sector return the largest bias. Though the biases are present for all data, they are very small in practical sense. The second panel of the tables contains the percentage of positive biases across individual elements $\bar{b}_{ij}$. The magnitude of positive biases gradually increases in K. This result is consistent across all datasets and years with only minor deviations from one another. The third panel summarizes the average t-statistics ($\bar{t}$) and their standard deviations (s_t). The average t-statistic is calculated as $\bar{t} = \sum_{i=1}^{n} \sum_{j=1}^{n} t_{ij}/n^2$ and its standard deviation as $s_t = \sqrt{\sum_i \sum_j (t_{ij} - \bar{t})^2/(n^2 - 1)}$. As can be seen in the tables, the t-statistics exceed the critical values corresponding to 5% significance levels for $K = 1,000$ and $10,000$ for all datasets, with exception of the IEF OKONh at $K = 1,000$ for the year 1998. For sample sizes $K = \{10, 20, 50, 100\}$ the bias in estimated multipliers on average is present (as determined in the first panel) but statistically not significant (third panel). This result is in line with Roland-Holst (1989). Roland-Holst limits the sample size to $K = 100$, and concludes that the perturbed multipliers are on average unbiased. As we increase the sample size, it can be seen that the amount of positive bias increases (second panel), which means that a right skew emerges. Even though the t-statistics exhibit large standard deviations for sample sizes $K = \{10, 20, 50, 100\}$, only 10-20% of the estimated multipliers exhibit biases that are statistically significantly different from zero. As sample size increases, the bias on average becomes statistically significantly different from zero, where approximately 50% of individual biases are significant for K =1,000 and approximately 100% for K =10,000 (third panel). This result supports the findings of Dietzenbacher (2006), which note the accumulation of (positive) bias in multiplier values in large $K = \{1,000, 10,000\}$ samples. This empirical finding also supports analytical results derived by Simonovits (1975). The results are consistent across all datasets and over the years.

Year	K=10 ROSSTAT (n=22)	K=10 IEF (n=25)	K=20 ROSSTAT (n=22)	K=20 IEF (n=25)	K=50 ROSSTAT (n=22)	K=50 IEF (n=25)	K=100 ROSSTAT (n=22)	K=100 IEF (n=25)	K=1,000 ROSSTAT (n=22)	K=1,000 IEF (n=25)	K=10,000 ROSSTAT (n=22)	K=10,000 IEF (n=25)
	Average bias ($\bar{b}$) and standard deviation (s_b)											
1998	0.00037	0.00021	0.00023	0.00027	0.00047	0.00024	0.00043	0.00014	0.00042	0.00019	0.00040	0.00018
	0.00473	0.00239	0.00298	0.00147	0.00227	0.00125	0.00184	0.00081	0.00127	0.00037	0.00093	0.00029
1999	0.00007	0.00027	0.00012	0.00035	0.00021	0.00025	0.00016	0.00012	0.00023	0.00020	0.00025	0.00019
	0.00337	0.00230	0.00272	0.00141	0.00149	0.00137	0.00105	0.00083	0.00041	0.00040	0.00039	0.00031
2000	0.00016	0.00034	0.00015	0.00041	0.00026	0.00029	0.00020	0.00015	0.00024	0.00021	0.00025	0.00020
	0.00348	0.00223	0.00289	0.00146	0.00154	0.00139	0.00108	0.00083	0.00044	0.00039	0.00039	0.00030
2001	0.00015	0.00042	0.00020	0.00047	0.00029	0.00031	0.00022	0.00016	0.00026	0.00023	0.00028	0.00022
	0.00373	0.00240	0.00303	0.00158	0.00166	0.00143	0.00116	0.00088	0.00046	0.00041	0.00041	0.00032
2002	0.00007	0.00035	0.00016	0.00039	0.00027	0.00028	0.00020	0.00014	0.00025	0.00022	0.00027	0.00021
	0.00359	0.00234	0.00291	0.00155	0.00163	0.00139	0.00120	0.00086	0.00044	0.00039	0.00040	0.00031
2003	0.00006	0.00035	0.00014	0.00038	0.00027	0.00026	0.00021	0.00014	0.00025	0.00023	0.00028	0.00022
	0.00364	0.00239	0.00302	0.00159	0.00164	0.00140	0.00117	0.00087	0.00045	0.00040	0.00039	0.00031
	Percentage positive biases											
1998	56%	68%	59%	72%	68%	71%	68%	63%	94%	94%	100%	100%
1999	55%	66%	58%	76%	63%	73%	68%	63%	95%	97%	100%	100%
2000	57%	69%	56%	78%	68%	77%	70%	70%	95%	96%	100%	100%
2001	55%	70%	56%	76%	66%	76%	69%	69%	94%	97%	100%	100%
2002	55%	70%	59%	76%	67%	75%	69%	67%	94%	97%	100%	100%
2003	56%	72%	58%	76%	68%	75%	70%	67%	95%	96%	100%	100%
	Average t-statistic ($\bar{t}$), standard deviation (s_t) and percentage "significant"											
1998	0.17	0.45	0.25	0.59	0.50	0.57	0.48	0.39	2.02	1.87	6.96	5.71
	1.38	1.17	1.19	1.10	0.99	1.03	1.01	1.12	1.18	1.23	2.72	2.55
	10%	7%	8%	8%	7%	8%	8%	9%	55%	44%	97%	95%
1999	0.16	0.44	0.19	0.66	0.37	0.60	0.44	0.38	2.05	2.07	6.77	6.16
	1.29	1.15	1.18	1.06	0.98	0.99	1.04	1.06	1.21	1.24	2.69	2.51
	8%	8%	8%	8%	6%	7%	8%	7%	54%	53%	97%	96%
2000	0.26	0.52	0.26	0.74	0.46	0.69	0.52	0.51	2.11	2.18	6.84	6.38
	1.33	1.11	1.23	1.07	0.95	0.97	1.02	1.05	1.22	1.24	2.65	2.51
	9%	7%	8%	9%	6%	7%	8%	8%	55%	56%	97%	97%
2001	0.19	0.52	0.22	0.76	0.43	0.67	0.50	0.48	2.05	2.17	6.84	6.36
	1.37	1.11	1.25	1.08	0.98	0.99	1.02	1.07	1.22	1.23	2.60	2.45
	10%	8%	9%	10%	6%	7%	7%	8%	55%	56%	97%	97%
2002	0.17	0.51	0.24	0.72	0.45	0.65	0.49	0.47	2.09	2.14	6.90	6.38
	1.37	1.09	1.23	1.09	0.97	0.99	1.03	1.08	1.20	1.21	2.57	2.41
	11%	7%	9%	11%	6%	8%	8%	9%	56%	56%	97%	97%
2003	0.17	0.54	0.21	0.72	0.46	0.62	0.50	0.46	2.07	2.14	6.97	6.40
	1.37	1.08	1.25	1.07	0.95	0.99	1.02	1.07	1.21	1.21	2.56	2.40
	10%	7%	10%	9%	6%	8%	7%	8%	55%	55%	98%	97%

* at $\alpha = 0.05$ $t_{cr} = 2.262$ for $K = 10$, $= 2.093$ for $K = 20$, $= 2.009$ for $K = 50$, $= 1.984$ for $K = 100$, $= 1.962$ for $K =1{,}000$, and $= 1.96$ for $K =10{,}000$.

Table 2.1: The bias of multiplier estimates based on the ROSSTAT and IEF OKONh data

Year	K=10 IEF w/ Pharm (n=44)	K=10 IEF w/o Pharm (n=43)	K=20 IEF w/ Pharm (n=44)	K=20 IEF w/o Pharm (n=43)	K=50 IEF w/ Pharm (n=44)	K=50 IEF w/o Pharm (n=43)	K=100 IEF w/ Pharm (n=44)	K=100 IEF w/o Pharm (n=43)	K=1,000 IEF w/ Pharm (n=44)	K=1,000 IEF w/o Pharm (n=43)	K=10,000 IEF w/ Pharm (n=44)	K=10,000 IEF w/o Pharm (n=43)
Average bias ($\bar{b}$) and standard deviation (s_b)												
1998	0.00049	0.00024	0.00096	0.00031	0.00076	0.00022	0.00397	0.00027	0.00084	0.00027	0.00050	0.00030
	0.00478	0.00285	0.01070	0.00235	0.00638	0.00149	0.04309	0.00109	0.00645	0.00069	0.00261	0.00073
1999	0.00019	0.00021	0.00011	0.00024	0.00018	0.00016	0.00025	0.00019	0.00022	0.00018	0.00022	0.00021
	0.00227	0.00253	0.00167	0.00174	0.00106	0.00109	0.00080	0.00077	0.00058	0.00041	0.00049	0.00041
2000	0.00017	0.00020	0.00011	0.00024	0.00018	0.00015	0.00025	0.00018	0.00023	0.00019	0.00022	0.00021
	0.00229	0.00260	0.00173	0.00177	0.00111	0.00110	0.00082	0.00077	0.00059	0.00042	0.00050	0.00043
2001	0.00015	0.00017	0.00011	0.00024	0.00017	0.00014	0.00025	0.00018	0.00022	0.00018	0.00022	0.00021
	0.00216	0.00235	0.00170	0.00173	0.00114	0.00106	0.00080	0.00070	0.00061	0.00038	0.00048	0.00041
2002	0.00017	0.00017	0.00012	0.00022	0.00019	0.00012	0.00027	0.00017	0.00024	0.00018	0.00023	0.00020
	0.00231	0.00224	0.00175	0.00157	0.00124	0.00099	0.00098	0.00068	0.00076	0.00040	0.00062	0.00041
2003	0.00030	0.00017	0.00034	0.00020	0.00035	0.00012	0.00043	0.00017	0.00036	0.00018	0.00034	0.00020
	0.00362	0.00216	0.00426	0.00154	0.00315	0.00098	0.00298	0.00068	0.00218	0.00041	0.00192	0.00042
Percentage positive biases												
1998	61%	62%	61%	65%	73%	66%	88%	81%	97%	99%	100%	100%
1999	59%	61%	57%	66%	70%	67%	83%	79%	96%	99%	100%	100%
2000	60%	62%	57%	67%	70%	67%	82%	79%	96%	98%	100%	100%
2001	59%	62%	56%	67%	69%	67%	82%	79%	96%	99%	100%	100%
2002	59%	62%	57%	67%	69%	66%	82%	78%	96%	98%	100%	100%
2003	60%	63%	58%	66%	69%	65%	82%	78%	96%	99%	100%	100%
Average t-statistic ($\bar{t}$), standard deviation (s_t) and percentage "significant"												
1998	0.27	0.28	0.26	0.37	0.61	0.44	1.09	0.84	2.77	2.85	8.81	9.07
	1.09	1.14	1.02	1.05	1.03	1.01	0.93	0.94	1.55	1.42	3.46	3.31
	6%	6%	4%	5%	8%	6%	14%	11%	67%	73%	99%	99%
1999	0.23	0.29	0.15	0.39	0.48	0.47	0.98	0.76	2.8	2.57	8.54	8.23
	1.08	1.17	1	1.05	0.98	1.03	1.14	0.93	1.82	1.36	3.63	2.96
	5%	7%	4%	6%	5%	7%	18%	9%	67%	66%	98%	98%
2000	0.23	0.31	0.15	0.41	0.48	0.47	0.97	0.76	2.8	2.58	8.6	8.29
	1.08	1.17	1	1.05	0.98	1.03	1.14	0.93	1.81	1.36	3.62	2.97
	5%	7%	4%	6%	5%	7%	18%	9%	67%	67%	98%	98%
2001	0.22	0.31	0.13	0.42	0.46	0.48	0.95	0.77	2.79	2.6	8.61	8.33
	1.08	1.16	1.02	1.05	0.99	1.03	1.15	0.92	1.82	1.36	3.64	2.99
	5%	7%	5%	6%	5%	7%	18%	9%	67%	67%	98%	98%
2002	0.23	0.31	0.15	0.41	0.49	0.44	0.99	0.75	2.91	2.6	8.96	8.43
	1.09	1.15	1.02	1.04	1.01	1.03	1.17	0.93	1.96	1.37	4.07	3.04
	5%	7%	4%	5%	6%	7%	19%	9%	68%	67%	98%	99%
2003	0.25	0.31	0.19	0.4	0.56	0.44	1.07	0.77	2.96	2.67	9.35	8.66
	1.09	1.13	1.04	1.03	1.06	1.02	1.22	0.93	1.82	1.39	4.04	3.11
	5%	7%	4%	5%	10%	7%	21%	10%	70%	68%	98%	99%

* at $\alpha = 0.05$ $t_{cr} = 2.262$ for $K = 10$, $= 2.093$ for $K = 20$, $= 2.009$ for $K = 50$, $= 1.984$ for $K = 100$, $= 1.962$ for K =1,000, and $= 1.96$ for K =10,000.

Table 2.2: The bias of multiplier estimates based on the IEF OKVED/NACE data w/ and w/o Pharm sector

Year	K=10 WIOD (n=34)	K=10 Eora (n=47)	K=20 WIOD (n=34)	K=20 Eora (n=47)	K=50 WIOD (n=34)	K=50 Eora (n=47)	K=100 WIOD (n=34)	K=100 Eora (n=47)	K=1,000 WIOD (n=34)	K=1,000 Eora (n=47)	K=10,000 WIOD (n=34)	K=10,000 Eora (n=47)
					Average bias ($\bar{b}$) and standard deviation (s_b)							
1998	0.00011	0.00008	0.00021	0.00013	0.00021	0.00013	0.00018	0.00011	0.00014	0.00008	0.00013	0.00007
	0.00154	0.00096	0.00114	0.00083	0.00082	0.00064	0.00061	0.00051	0.00026	0.00023	0.00021	0.00020
1999	0.00014	0.00007	0.00020	0.00012	0.00021	0.00012	0.00017	0.00010	0.00013	0.00008	0.00012	0.00007
	0.00148	0.00094	0.00109	0.00080	0.00080	0.00060	0.00062	0.00048	0.00025	0.00023	0.00021	0.00019
2000	0.00015	0.00008	0.00021	0.00013	0.00021	0.00013	0.00018	0.00012	0.00013	0.00008	0.00012	0.00007
	0.00148	0.00104	0.00109	0.00089	0.00080	0.00071	0.00062	0.00056	0.00025	0.00025	0.00021	0.00021
2001	0.00015	0.00008	0.00024	0.00013	0.00023	0.00014	0.00019	0.00012	0.00014	0.00008	0.00013	0.00007
	0.00152	0.00105	0.00114	0.00091	0.00082	0.00072	0.00063	0.00058	0.00026	0.00025	0.00021	0.00021
2002	0.00014	0.00008	0.00023	0.00014	0.00022	0.00014	0.00018	0.00012	0.00014	0.00009	0.00013	0.00008
	0.00150	0.00110	0.00113	0.00096	0.00080	0.00078	0.00061	0.00062	0.00024	0.00026	0.00020	0.00022
2003	0.00018	0.00007	0.00026	0.00013	0.00024	0.00014	0.00020	0.00012	0.00015	0.00008	0.00013	0.00007
	0.00154	0.00113	0.00116	0.00099	0.00082	0.00082	0.00063	0.00065	0.00026	0.00026	0.00021	0.00022
					Percentage positive biases							
1998	59%	64%	73%	71%	83%	79%	82%	83%	98%	98%	100%	100%
1999	60%	64%	72%	71%	83%	79%	82%	83%	98%	98%	100%	100%
2000	61%	64%	72%	70%	83%	79%	82%	83%	98%	98%	100%	100%
2001	60%	64%	72%	70%	83%	79%	83%	83%	98%	98%	100%	100%
2002	60%	64%	73%	70%	83%	79%	82%	83%	98%	98%	100%	100%
2003	62%	64%	74%	70%	84%	79%	83%	83%	98%	98%	100%	100%
					Average t-statistic ($\bar{t}$), standard deviation (s_t) and percentage "significant"							
1998	0.21	0.32	0.63	0.51	0.91	0.80	1.02	0.99	2.54	2.62	7.21	7.35
	1.13	1.00	1.05	1.07	1.07	1.00	1.07	1.01	1.21	1.22	2.37	2.65
	5%	3%	9%	7%	16%	11%	18%	17%	67%	71%	99%	97%
1999	0.25	0.32	0.60	0.51	0.92	0.81	1.03	0.99	2.58	2.62	7.29	7.34
	1.11	1.00	1.04	1.07	1.07	1.00	1.08	1.01	1.21	1.22	2.46	2.66
	5%	3%	9%	7%	15%	12%	19%	17%	70%	71%	99%	97%
2000	0.27	0.31	0.61	0.51	0.94	0.81	1.03	1.00	2.58	2.66	7.25	7.45
	1.11	1.00	1.04	1.06	1.07	1.00	1.08	1.01	1.21	1.21	2.43	2.65
	5%	3%	9%	7%	16%	12%	20%	17%	69%	72%	99%	97%
2001	0.25	0.31	0.62	0.51	0.94	0.81	1.04	0.99	2.55	2.62	7.21	7.35
	1.10	1.00	1.04	1.06	1.06	1.00	1.07	1.01	1.21	1.22	2.40	2.68
	4%	3%	9%	7%	15%	11%	19%	17%	68%	71%	99%	97%
2002	0.24	0.31	0.62	0.51	0.92	0.80	1.03	0.99	2.54	2.63	7.19	7.36
	1.10	1.00	1.04	1.06	1.07	1.00	1.07	1.01	1.21	1.22	2.39	2.67
	5%	3%	9%	7%	16%	11%	19%	17%	67%	71%	99%	97%
2003	0.27	0.31	0.65	0.51	0.95	0.80	1.05	0.99	2.56	2.61	7.23	7.32
	1.10	1.00	1.03	1.06	1.06	1.00	1.06	1.01	1.21	1.23	2.40	2.69
	5%	3%	9%	7%	17%	11%	19%	17%	69%	71%	99%	97%

* at $\alpha = 0.05$ $t_{cr} = 2.262$ for $K = 10$, $= 2.093$ for $K = 20$, $= 2.009$ for $K = 50$, $= 1.984$ for $K = 100$, $= 1.962$ for $K =1{,}000$, and $= 1.96$ for $K =10{,}000$.

Table 2.3: The bias of multiplier estimates based on the WIOD and Eora data

Table 2.2 provides results on the bias in multipliers derived from the IEF OKVED data with and without pharmaceutical sector. If we glance across the table, we can notice the average bias and the standard deviation in multipliers being 2-3 times larger in the data that includes the pharmaceutical sector. This phenomenon only appears in years 1998 and 2003, and not the interim years. The result is persistent for all K. Even though the average bias is significantly larger when we include the pharmaceutical sector, the direction of the bias and the statistical significance of the bias remain similar. Therefore, we conclude that we cannot reject that the multipliers estimated from the IEF OKVED data with and without pharmaceutical sector are unbiased at 5% significance level. Now let us redirect attention to the test on stability of the perturbed multipliers. The results can be found in Table 2.4. Table 2.4 represents the average ratios $\bar{\rho}(= \sum_i \sum_j \rho_{ij}/n^2)$ and their standard deviations $s_\rho(= \sum_i \sum_j (\rho_{ij} - \bar{\rho})^2/(n^2 - 1))$ that aid us in identifying whether the estimated multipliers are as stable $(= \rho_0 = 0.1)$, more stable $(< \rho_0 = 0.1)$ or less stable $(> \rho_0 = 0.1)$ than the multipliers obtained from the unperturbed data. As a reminder, equation 2.4 is used to calculate individual stability values ρ_{ij}. Most of the reported average stability values are close to 0.1 which signifies that the derived from perturbed data multipliers on average are as stable as the ones derived from the 'true' data with exception for those that represent the years 1998 and 2003. Next, we need to identify which sector(s) are driving the instability. For this, among $i \times j = 1,936$ individual ρ_{ij} for six years, we plot those ρ_{ij} that satisfy the condition of being $\geq 20\%$ between the maximum and the minimum ρ_{ij} in this subset of six years. We notice that most outliers originate in the pharmaceutical sector. When the pharmaceutical sector is removed from the input-output data, the derived multipliers become well-behaved across all years. This result is also robust when instead of removing the sector all together we aggregate it with the chemical production sector to minimize the loss of information. In the years 1998 and 2003 despite of the small size (pharmaceutical production is only 0.14-0.19% of the total production), the pharmaceutical sector exhibits strong influence on other sectors of the economy. This finding suggests the designated importance to this sector by the IEF when deriving the production technology during the construction of the input-output tables. Mathematically, it means that a small value of Δa_{ij} implies a large value of Δl_{rs}. It is beyond the scope of this chapter, but for deeper coverage on how to identify 'important' coefficients an interested reader may refer to Miller and Blair (2009, p. 567). Why such a small sector as pharmaceutical production has such a large effect on the rest of the economy in our data remains a puzzle.

Year	K=10		K=20		K=50		K=100		K=1,000		K=10,000	
	IEF w/ Pharm (n=44)	IEF w/o Pharm (n=43)	IEF w/ Pharm (n=44)	IEF w/o Pharm (n=43)	IEF w/ Pharm (n=44)	IEF w/o Pharm (n=43)	IEF w/ Pharm (n=44)	IEF w/o Pharm (n=43)	IEF w/ Pharm (n=44)	IEF w/o Pharm (n=43)	IEF w/ Pharm (n=44)	IEF w/o Pharm (n=43)
1998	0.122	0.100	0.197	0.098	0.163	0.101	1.253	0.103	0.461	0.101	0.238	0.101
	0.131	0.030	0.483	0.025	0.312	0.024	5.170	0.026	1.649	0.024	0.642	0.024
1999	0.099	0.100	0.098	0.097	0.100	0.100	0.102	0.101	0.102	0.099	0.102	0.100
	0.034	0.030	0.032	0.024	0.030	0.023	0.028	0.022	0.026	0.021	0.025	0.020
2000	0.099	0.100	0.098	0.098	0.100	0.100	0.102	0.101	0.102	0.100	0.102	0.100
	0.033	0.031	0.031	0.024	0.030	0.023	0.027	0.022	0.025	0.021	0.025	0.021
2001	0.099	0.100	0.098	0.098	0.100	0.100	0.102	0.101	0.102	0.100	0.102	0.100
	0.034	0.030	0.031	0.024	0.030	0.023	0.028	0.023	0.026	0.021	0.025	0.021
2002	0.101	0.099	0.101	0.097	0.102	0.100	0.103	0.101	0.104	0.100	0.104	0.100
	0.040	0.030	0.042	0.024	0.038	0.023	0.035	0.023	0.033	0.021	0.031	0.021
2003	0.111	0.099	0.123	0.097	0.117	0.100	0.121	0.101	0.130	0.100	0.128	0.100
	0.083	0.030	0.140	0.024	0.103	0.024	0.113	0.024	0.149	0.022	0.139	0.022

Table 2.4: The stability measures ($\bar{\rho}$) and their standard deviations (s_ρ) of multiplier estimates based on the IEF OKVED/NACE data w/ and w/o Pharm sector

To continue the discussion on the variability of the derived multipliers for the rest of the datasets that cover Russia refer to Tables 2.5 and 2.6. Table 2.5 gives an overview of the average stability measures $\bar{\rho}$ and their standard deviations s_ρ across all sample sizes and years. An individual stability measure ρ_{ij} is defined as the ratio between the standard deviation and the "true" multiplier value l_{ij}^0 (as shown in equation 2.4). As noted before, the estimated multipliers are deemed equally stable if $\bar{\rho} = \rho_0 = 0.1$, more stable if $\bar{\rho} < \rho_0 = 0.1$ or less stable if $\bar{\rho} > \rho_0 = 0.1$ than the multipliers obtained from the unperturbed data. In this derivation we follow Dietzenbacher (2006) and incorporate the Kronecker delta. On the contrary to Dietzenbacher (2006) we find that most of the derived average stability measures are slightly below or equal to 0.1, which suggests that the estimated matrices of multipliers on average are equally and more stable than the stochastic intermediate transaction and final demand elements that were used in their calculation. The exception are the measures $\bar{\rho}$ derived from the Eora data that are on average less stable than the underlying input-output data. We also find, similar to Roland-Holst (1989), that as the sample size increases the multipliers on average show tendency toward greater stability. This is consistent over the years. Another interesting result is that the derived multipliers on average tend to get more stable towards the end of the study period. For example, for K=10,000, $\bar{\rho}$=0.096 in 1998 decreases to $\bar{\rho}$=0.094 in 2003 for the ROSSTAT. This is intriguing because, as we mentioned in Section 2.3, the latest base input-output table that was published in Russia dates back to 1995, and all subsequent annual tables are extrapolated on its basis with additional distributional assumptions. Therefore, one would expect to observe the opposite, greater bias and more instability in the multipliers derived from more distant years. The standard deviations for the stability measure s_ρ are considerable. The results of this chapter only slightly differ from those in Dietzenbacher (2006) in which he finds the multiplier estimates on average to be unstable but much of this instability to be removed by the standard deviation. We find that for most of the databases the estimated multipliers exhibit on average greater stability despite many of the individual multipliers being unstable, as signified by a large standard deviation.

Table 2.6 is a supporting aid for the discussion on the variability in multiplier estimates. It summarizes the results for the hypothesis test on the stability of the estimates described in Section 2.4. The table records the percentage of the n^2 χ^2_{ij} elements that are below the 2.5% percentile critical value (χ^2_L), above the 97.5% percentile critical value (χ^2_U) and in the range $[\chi^2_L; \chi^2_U]$. In practically all cases except for the Eora the percentage of values below the lower critical point is larger than the percentage of values above the upper critical point. It is for these cases when the percentage of individual χ^2_{ij} is larger for above than below the critical point the multiplier estimates on average are more unstable. It can be seen in the case of the Eora results. As depicted in Table 2.6, as K increases, the H_0 of multiplier stability gets rejected more easily. As Dietzenbacher (2006) notes, this is of no surprise as a large sample allows for a better distinction between ρ_{ij} and ρ_0.

Year	Dataset	K=10	K=20	K=50	K=100	K=1,000	K=10,000
1998	ROSSTAT	0.084	0.088	0.092	0.093	0.096	0.096
		0.026	0.021	0.018	0.018	0.019	0.018
	IEF OKONh	0.094	0.097	0.097	0.097	0.098	0.097
		0.026	0.023	0.020	0.019	0.019	0.018
	IEF OKVED	0.100	0.098	0.101*	0.103*	0.101*	0.101*
		0.030	0.025	0.024	0.026	0.024	0.024
	Rus WIOD	0.091	0.093	0.094	0.096	0.096	0.096
		0.029	0.023	0.018	0.017	0.016	0.017
	Rus Eora	0.120*	0.118*	0.118*	0.118*	0.119*	0.119*
		0.039	0.031	0.026	0.024	0.023	0.023
1999	ROSSTAT	0.086	0.088	0.093	0.094	0.096	0.097
		0.026	0.019	0.018	0.018	0.017	0.017
	IEF OKONh	0.095	0.098	0.097	0.096	0.098	0.098
		0.026	0.023	0.019	0.018	0.018	0.017
	IEF OKVED	0.100	0.097	0.100	0.101*	0.099	0.100
		0.030	0.024	0.023	0.022	0.021	0.020
	Rus WIOD	0.093	0.094	0.095	0.097	0.097	0.097
		0.030	0.024	0.018	0.018	0.017	0.017
	Rus Eora	0.119*	0.118*	0.118*	0.118*	0.118*	0.118*
		0.039	0.031	0.026	0.025	0.023	0.023
2000	ROSSTAT	0.086	0.088	0.093	0.095	0.097	0.097
		0.026	0.020	0.018	0.018	0.018	0.017
	IEF OKONh	0.094	0.097	0.097	0.096	0.098	0.097
		0.025	0.023	0.020	0.019	0.019	0.018
	IEF OKVED	0.100	0.098	0.100	0.101*	0.100	0.100
		0.031	0.024	0.023	0.022	0.021	0.021
	Rus WIOD	0.092	0.093	0.094	0.096	0.096	0.096
		0.029	0.024	0.018	0.018	0.017	0.017
	Rus Eora	0.120*	0.119*	0.119*	0.119*	0.119*	0.119*
		0.039	0.031	0.026	0.025	0.023	0.023
2001	ROSSTAT	0.083	0.086	0.091	0.092	0.095	0.095
		0.026	0.020	0.018	0.018	0.018	0.018
	IEF OKONh	0.091	0.095	0.094	0.094	0.095	0.095
		0.024	0.023	0.020	0.019	0.019	0.018
	IEF OKVED	0.100	0.098	0.100	0.101*	0.100	0.100
		0.030	0.024	0.023	0.023	0.021	0.021
	Rus WIOD	0.089	0.091	0.092	0.094	0.094	0.094
		0.029	0.023	0.018	0.017	0.016	0.016
	Rus Eora	0.119*	0.118*	0.118*	0.118*	0.118*	0.118*
		0.039	0.031	0.026	0.024	0.023	0.023
2002	ROSSTAT	0.084	0.086	0.091	0.092	0.095	0.095
		0.026	0.020	0.018	0.018	0.018	0.017
	IEF OKONh	0.093	0.095	0.094	0.094	0.095	0.095
		0.024	0.023	0.020	0.019	0.018	0.018
	IEF OKVED	0.099	0.097	0.100	0.101*	0.100	0.100
		0.030	0.024	0.023	0.023	0.021	0.021
	Rus WIOD	0.089	0.091	0.092	0.093	0.094	0.094
		0.029	0.023	0.018	0.017	0.016	0.016
	Rus Eora	0.120*	0.118*	0.118*	0.118*	0.119*	0.119*
		0.039	0.031	0.026	0.024	0.023	0.023
2003	ROSSTAT	0.083	0.085	0.091	0.092	0.094	0.094
		0.026	0.020	0.018	0.018	0.018	0.017
	IEF OKONh	0.093	0.094	0.094	0.093	0.094	0.094
		0.025	0.023	0.020	0.019	0.018	0.018
	IEF OKVED	0.099	0.097	0.100	0.101*	0.100	0.100
		0.030	0.024	0.024	0.024	0.022	0.022
	Rus WIOD	0.089	0.091	0.091	0.093	0.093	0.093
		0.029	0.023	0.018	0.017	0.016	0.017
	Rus Eora	0.119*	0.118*	0.118*	0.118*	0.118*	0.118*
		0.039	0.031	0.026	0.024	0.023	0.023

Table 2.5: The stability measures ($\bar{\rho}$) and their standard deviations (s_ρ) of multiplier estimates for Russia

Year	Dataset	K=10	K=20	K=50	K=100	K=1,000	K=10,000
1998	ROSSTAT	12.40	19.63	27.69	38.22	51.45	48.76
		1.03	2.27	7.02	14.26	33.26	33.88
		86.57	78.10	65.29	47.52	15.29	17.36
	IEF OKONh	5.44	10.56	22.88	30.24	45.28	44.64
		5.12	7.52	12.96	16.32	33.28	33.44
		89.44	81.92	64.16	53.44	21.44	21.92
	IEF OKVED	5.25	12.82	20.93	25.85	44.02	43.97
		7.73	8.65	22.39	28.83	38.78	40.08
		87.02	78.53	56.68	45.32	17.20	15.95
	Rus WIOD	9.78	13.15	22.49	30.54	52.68	53.63
		4.84	5.97	8.65	14.01	29.58	29.67
		85.38	80.88	68.86	55.45	17.73	16.70
	Rus Eora	2.54	4.12	8.42	11.68	19.38	19.60
		22.32	32.64	49.30	56.18	68.27	67.22
		75.15	63.24	42.28	32.14	12.36	13.17
1999	ROSSTAT	8.68	15.50	27.48	35.12	48.97	49.17
		2.27	2.69	8.06	16.32	32.23	32.44
		89.05	81.82	64.46	48.55	18.80	18.39
	IEF OKONh	4.00	8.32	20.16	32.00	47.84	47.52
		4.80	7.52	15.52	16.64	33.60	32.80
		91.20	84.16	64.32	51.36	18.56	19.68
	IEF OKVED	5.19	12.60	21.04	26.18	44.19	43.10
		7.95	8.55	20.50	28.23	39.05	40.35
		86.86	78.85	58.46	45.59	16.77	16.55
	Rus WIOD	8.65	14.36	21.28	27.60	49.74	49.48
		5.19	6.75	9.60	17.56	35.29	34.86
		86.16	78.89	69.12	54.84	14.97	15.66
	Rus Eora	2.67	4.62	8.92	12.36	20.24	20.05
		21.91	32.46	48.80	55.82	67.81	67.09
		75.42	62.92	42.28	31.82	11.95	12.86
2000	ROSSTAT	9.30	16.12	25.62	34.09	46.90	46.90
		2.07	3.10	8.47	17.56	32.44	32.23
		88.64	80.79	65.91	48.35	20.66	20.87
	IEF OKONh	3.20	8.96	21.76	34.24	49.60	48.64
		3.68	7.68	13.60	16.80	34.40	32.64
		93.12	83.36	64.64	48.96	16.00	18.72
	IEF OKVED	5.08	12.66	20.23	25.69	43.65	43.59
		8.11	9.14	21.31	29.15	39.10	40.45
		86.80	78.20	58.46	45.16	17.25	15.95
	Rus WIOD	8.65	15.22	22.40	30.71	50.87	51.82
		4.50	6.14	9.86	16.61	33.74	33.13
		86.85	78.63	67.73	52.68	15.40	15.05
	Rus Eora	2.44	4.26	8.10	11.45	19.56	19.56
		22.77	33.68	50.48	56.63	69.49	68.63
		74.78	62.06	41.42	31.91	10.96	11.82
2001	ROSSTAT	11.36	21.28	31.20	38.02	53.51	53.72
		2.07	1.86	7.02	15.91	29.13	28.10
		86.57	76.86	61.78	46.07	17.36	18.18
	IEF OKONh	3.36	10.88	26.72	37.76	54.08	54.40
		2.56	7.04	10.72	14.72	29.44	28.00
		94.08	82.08	62.56	47.52	16.48	17.60
	IEF OKVED	5.35	12.66	21.09	26.50	44.78	44.13
		8.06	8.98	21.09	28.93	38.72	40.40
		86.59	78.37	57.82	44.56	16.50	15.47
	Rus WIOD	10.47	16.52	26.47	34.43	56.14	56.31
		3.37	5.28	7.27	12.37	26.90	26.73
		86.16	78.20	66.26	53.20	16.96	16.96
	Rus Eora	2.72	4.80	8.92	12.22	20.05	20.05
		22.23	32.23	48.89	55.86	67.99	67.41
		75.06	62.97	42.19	31.91	11.95	12.54
2002	ROSSTAT	10.12	18.39	30.79	39.67	54.34	53.93
		1.86	1.86	5.99	13.84	29.13	27.07
		88.02	79.75	63.22	46.49	16.53	19.01
	IEF OKONh	3.84	10.08	26.08	37.76	55.36	54.56
		3.20	7.04	11.36	14.08	28.48	27.04
		92.96	82.88	62.56	48.16	16.16	18.40
	IEF OKVED	5.25	12.49	21.53	27.10	45.65	44.78
		7.90	8.44	21.90	27.91	38.18	39.32
		86.86	79.07	56.57	45.00	16.17	15.90
	Rus WIOD	10.64	16.61	27.77	35.73	56.75	57.44
		3.81	4.93	7.27	11.94	26.12	25.69
		85.55	78.46	64.97	52.34	17.13	16.87
	Rus Eora	2.54	4.30	8.42	11.77	19.42	19.33
		22.59	32.64	49.30	56.22	68.45	67.68
		74.88	63.06	42.28	32.01	12.13	12.99
2003	ROSSTAT	11.36	21.90	30.79	41.32	54.96	54.55
		1.65	1.86	6.40	13.22	28.72	26.65
		86.98	76.24	62.81	45.45	16.32	18.80
	IEF OKONh	3.84	10.88	28.00	39.68	56.32	55.20
		2.88	6.88	10.72	13.60	27.84	25.92
		93.28	82.24	61.28	46.72	15.84	18.88
	IEF OKVED	5.14	12.01	22.07	27.69	46.19	45.38
		7.46	7.84	21.47	26.93	37.48	38.99
		87.40	80.15	56.46	45.38	16.33	15.63
	Rus WIOD	10.99	16.61	27.16	36.07	59.08	59.17
		3.37	5.19	6.75	11.59	26.38	25.87
		85.64	78.20	66.09	52.34	14.53	14.97
	Rus Eora	2.67	4.66	9.10	12.13	20.01	20.42
		22.36	32.46	48.66	56.00	68.09	67.59
		74.97	62.88	42.24	31.87	11.91	12.00

* at α = 0.05 χ^2_L = 2.7 and χ^2_U = 19.02 for K=10, χ^2_L = 8.907 and χ^2_U = 32.852 for K=20, χ^2_L = 31.555 and χ^2_U=70.222 for K=50, χ^2_L=73.361 and χ^2_U=127.422 for K=100, χ^2_L=914.257 and χ^2_U=1089.53 for K =1,000+.

Table 2.6: The percentage smaller than χ^2_L, larger than χ^2_U, and in $[\chi^2_L; \chi^2_U]$ for Russia

In line with Roland-Holst (1989), to check the robustness of the results in Table 2.5 we calculate the stability measures ρ_{ij} and subsequently derive the average without using the Kronecker delta in equation 2.4. We find that the values of $\bar{\rho}$ change only marginally (within 1-5%) when we omit the Kronecker delta across all datasets and for all years. The coverage of the results is available in Appendix A, Table A.4. Therefore, it is left up to a researcher to decide whether (s)he would like to remove the direct effect out of the power series $(\mathbf{I}-\mathbf{A})^{-1}$ with the Kronecker delta.

Another robustness check is to verify the sensitivity to varying sizes of uncertainty in the intermediate transactions z_{ij} and final demand elements y_i. We test sizes of stochastic errors $\rho = 12\%$, 15%, and 20%. As in the case of $\rho = 10\%$, the elements of the multiplier matrices become 'significantly' biased at $K = \{1,000, 10,000\}$. Even though the bias is statistically significantly different from zero at large K, the absolute size of the bias still remains very small. This can be observed across all datasets and years. Therefore, the conclusion drawn in Dietzenbacher (2006) of a treatment of the estimated multipliers in practice as though they are unbiased remains justified. As for stability, the multipliers derived from the Eora data are the most unstable exhibiting 20-30% additional stochasticity in multipliers than the underlying uncertainty level ρ. Next are the multipliers derived from the IEF data with OKVED industry classification. They also exhibit a widespread instability but to a significantly lesser extent. As expected across all tested datasets, the elements show greater tendency to become unstable as the sample size and the absolute size of the assumed uncertainty in the input-output data increases. At $K = \{1,000, 10,000\}$ and $\rho = 0.2$ nearly all elements are unstable. The detailed results on the average stability measures $\bar{\rho}$ and their standard deviations s_ρ for different error sizes are available in Appendix A, Table A.5.

It seems theoretically reasonable that the uncertainty propagates better through systems that are more disaggregated. Therefore, our finding of the Eora ($n = 47$) and the IEF OKVED ($n = 44$) data being more susceptible to accumulation of bias comes as no surprise. Among all datasets that we use in the Monte Carlo experiment, these datasets have the highest number of sectors. Hence, we would like to test robustness of the results to the matrix size (n). We aggregate the Eora and the IEF OKVED data to n=34 (as per the WIOD) and n=22 (as per the ROSSTAT and the

IEF OKONh). In each aggregation, sectors are consolidated preserving the economic structure as much as possible. In our exercise we refrained from limiting n to low digits to stay realistic to the data that we present in this chapter. Dietzenbacher (2006) examines $n = \{4, 8, 16, 32, 64, 128\}$, and finds that smaller $n = \{4, 8\}$ increase the absolute value of the average bias $\bar{b}$ to some minimally noticeable level but more so raises the standard deviations, which leads to reduced stability of the estimates. However, if one specifically pays attentions to the results for $n = \{16, 32, 64\}$, one may notice that there is no significant change in results. This is what we find in this chapter when we cross-validate the results for $n = \{22, 36, 47(44)\}$. The size and the statistical significance of the average bias, the standard deviations, and, as a consequence, the stability measures remain approximately unchanged. With caution, this suggests that it is something other than the size of the input-output data that is driving the results obtained earlier in this chapter. The estimated input-output multipliers are insensitive to industry aggregation level (Appendix A, Table A.6).

The last robustness control we utilize pertaining to the Monte Carlo experiment is conducting simulation on the perturbed data from Germany. The quality of German data is often mentioned in the literature as exemplary, and it is frequently used in comparative empirical studies (Wolff, 2005). To stay consistent with existing data specifications, we take the input-output data for the same time period of 1998-2003 from German Federal Statistical Office (DESTATIS) . These data consists of 68 sectors and follows the NACE Rev.1 industrial classification[7]. In addition to the DESTATIS data, we also include the German input-output data from the WIOD.

The results are presented in Table 2.7. When we compare the absolute size of average biases to those of Russia in Tables 2.1 and 2.2, we immediately see that the average bias in results for Germany is significantly lower than the average bias in results from the Russian national data. However, it is of similar size to the average bias derived from the WIOD and the Eora data for Russia (Table 2.3). As the amount of sectors, n, increases, the values of average bias, $\bar{b}$, and the standard deviations, s_b, tend to get smaller. This is understandable because a small n incorporates the same amount

[7]The agency publishes 70 industries. We make two modifications to avoid singularity. First, we delete the uranium production industry, which has only zero entries. Second, we sum sectors 'Mining of metal' and 'Other mining'.

of information on economic activity as a large n. Hence, in more aggregated cases we expect single outliers to have more influence than in disaggregated cases when individual variations can more easily cancel each other out. Even though $\bar{b}$ remains approximately unchanged in K, s_b gets significantly smaller as K increases. Similar to Russian data, as K increases a growing number of individual biases b_{ij} become positive, approaching 100% for K=10,000. Hence, the distribution becomes right-skewed. And, as it happens, we can see that the average t-statistic, $\bar{t}$, exceeds the critical value at 5% significance when $K = \{1,000, 10,000\}$.

As for the stability test presented in the third panel of Table 2.7, we observe that as sample size increases, the average stability ratio $\bar{\rho}$ becomes greater than 0.1. It means that the multipliers derived from German stochastic input-output data have greater underlying uncertainty on average than the data they are estimated from. Appendix A, Table A.5 offers a side by side aid to compare the results on average stability for both countries. The multiplier estimates derived from DESTATIS data appear to be very sensitive to the size of the error in the data. On average they get progressively more unstable with growing ρ. Though the standard deviations s_ρ are also large, which indicates that though many ρ_{ij} exhibit less stability, there is a significant percentage of ρ_{ij} that have an increased stability. Appendix A, Table A.4 exhibits how the average stability measures change when we complete the calculation with and without the Kronecker delta. As in the case with Russia, the results only change slightly. When we assess the sensitivity of the results for DESTATIS to reduction of n from 68 to 34 and 25, we do not detect any significant change. Even though there is an increase in absolute size of the average bias, $\bar{b}$, and its standard deviation, s_b, it remains negligibly small in practical sense even for large K. Earlier we noted that the average multiplier stability was inherent to smaller sized square systems, such as ROSSTAT (n=22) and IEF OKONh (n=25), reducing the size of DESTATIS from n=67 to 22 does not have an effect on stability measure. The multipliers continue to remain on average unstable with nearly identical measure for $\bar{\rho}$ and s_ρ (Table 2.7). For results for varying size n refer to Appendix A, Table A.6.

The Russian input-output data (ROSSTAT and IEF) are published incorporating the assumption of competitive imports. It means that the imported and domestic intermediate transactions are produced using similar technology. In terms of national accounting methodology it signifies that the matrix of intermediate transactions $\mathbf{Z}$ consists of domestic intermediate transactions $\mathbf{Z_d}$ and imported intermediate transactions $\mathbf{Z_i}$. On the basis of $\mathbf{Z}$ we subsequently derive matrices of technical coefficients $\mathbf{A}$ and input-output multipliers $\mathbf{L}$. A detailed coverage of the imports handling in input-output framework is provided in the next chapters. Such coverage in this chapter is unnecessary as the conclusions pertaining the bias and stability of perturbed multipliers remain unchanged whether or not we extract imported inputs from intermediate transactions.

To summarize the findings, the results of the Monte Carlo simulation conducted in this chapter using Russian and German data produce similar conclusions to those made in Dietzenbacher (2006). Across all datasets, it is shown that the estimated multipliers are positively biased, but the actual size of the bias is minimal. Due to such small size, the power of the test needs to be large enough to be able to detect the bias. Hence, the average bias becomes statistically significantly different from zero at 5% at K=1,000 and 10,000. But because the bias is so small, the derived input-output multipliers can be treated as unbiased when handled in economic analysis. The absolute size of the bias and the standard deviation in multipliers derived from the Russian national data (ROSSTAT and IEF OKONh) is greater than the bias and the standard deviation for Eora and German data (DESTATIS). However, in proportion to the mean, the standard deviation is smaller for Russia. As a consequence, the multipliers derived from the Russian national data exhibit on average greater stability than from the Eora or German data. These results hold when we adjust for the sectoral size of input-output data and the error size of the perturbances. The aim of this chapter is to determine whether the quality of Russian national data is reliable enough for further input-output modeling analysis. Based on the results of the Monte Carlo simulation with various robustness specifications, we are cautiously optimistic to call the quality of the Russian input-output data reasonably satisfactory for use in further input-output modeling analysis.

Year	K=10 WIOD (n=34)	K=10 DESTATIS (n=57)	K=20 WIOD (n=34)	K=20 DESTATIS (n=57)	K=50 WIOD (n=34)	K=50 DESTATIS (n=57)	K=100 WIOD (n=34)	K=100 DESTATIS (n=57)	K=1,000 WIOD (n=34)	K=1,000 DESTATIS (n=57)	K=10,000 WIOD (n=34)	K=10,000 DESTATIS (n=57)
	Average bias ($\bar{b}$) and standard deviation (s_b)											
1998	0.00007	0.00015	0.00009	0.00013	0.00009	0.00017	0.00007	0.00015	0.00007	0.00012	0.00007	0.00012
	0.00149	0.00149	0.00103	0.00099	0.00060	0.00078	0.00043	0.00054	0.00024	0.00024	0.00017	0.00023
1999	0.00007	0.00016	0.00009	0.00013	0.00009	0.00018	0.00008	0.00015	0.00007	0.00012	0.00007	0.00012
	0.00146	0.00150	0.00101	0.00100	0.00060	0.00079	0.00044	0.00055	0.00025	0.00024	0.00018	0.00023
2000	0.00007	0.00014	0.00009	0.00011	0.00009	0.00016	0.00008	0.00014	0.00007	0.00012	0.00007	0.00012
	0.00154	0.00129	0.00108	0.00086	0.00061	0.00070	0.00044	0.00052	0.00024	0.00024	0.00018	0.00021
2001	0.00007	0.00014	0.00008	0.00011	0.00009	0.00016	0.00008	0.00014	0.00007	0.00012	0.00007	0.00012
	0.00150	0.00129	0.00106	0.00087	0.00061	0.00072	0.00044	0.00054	0.00024	0.00024	0.00018	0.00022
2002	0.00006	0.00013	0.00008	0.00010	0.00009	0.00016	0.00008	0.00013	0.00007	0.00012	0.00007	0.00012
	0.00148	0.00126	0.00104	0.00087	0.00059	0.00073	0.00043	0.00053	0.00024	0.00024	0.00018	0.00022
2003	0.00006	0.00012	0.00008	0.00011	0.00009	0.00016	0.00008	0.00013	0.00007	0.00012	0.00007	0.00012
	0.00150	0.00127	0.00106	0.00086	0.00060	0.00072	0.00044	0.00053	0.00025	0.00025	0.00018	0.00022
	Average t-statistic ($\bar{t}$), standard deviation (s_t) and percentage ”significant”											
1998	0.35	0.09	0.51	0.23	0.83	0.73	1.11	0.91	2.62	2.35	8.03	7.24
	1.21	1.12	1.15	1.03	0.98	1.05	1.03	1.04	1.32	1.15	2.92	2.41
	7%	5%	10%	4%	12%	13%	20%	16%	69%	64%	99%	99%
1999	0.36	0.09	0.51	0.23	0.83	0.73	1.12	0.91	2.63	2.33	8.06	7.20
	1.21	1.12	1.15	1.03	0.98	1.05	1.02	1.03	1.32	1.15	2.92	2.42
	8%	5%	10%	5%	12%	12%	20%	16%	69%	64%	99%	99%
2000	0.37	0.09	0.52	0.21	0.82	0.75	1.11	0.89	2.62	2.35	8.02	7.26
	1.23	1.11	1.17	1.01	0.99	1.02	1.03	1.03	1.33	1.17	2.91	2.40
	8%	4%	11%	4%	12%	12%	20%	15%	69%	62%	99%	99%
2001	0.36	0.09	0.51	0.21	0.82	0.75	1.12	0.89	2.65	2.35	8.06	7.29
	1.23	1.11	1.17	1.00	0.99	1.02	1.03	1.03	1.34	1.18	2.92	2.42
	8%	4%	11%	4%	12%	12%	21%	15%	69%	62%	99%	99%
2002	0.36	0.09	0.52	0.21	0.83	0.75	1.13	0.88	2.66	2.36	8.10	7.30
	1.23	1.11	1.17	1.00	0.99	1.02	1.04	1.04	1.34	1.18	2.93	2.42
	8%	4%	11%	4%	12%	12%	21%	15%	70%	61%	99%	99%
2003	0.37	0.08	0.51	0.21	0.83	0.74	1.13	0.88	2.67	2.35	8.15	7.28
	1.22	1.11	1.17	1.00	1.00	1.02	1.06	1.04	1.34	1.18	2.95	2.41
	8%	4%	11%	4%	13%	12%	21%	15%	70%	60%	99%	99%
	The stability measures ($\bar{\rho}$) and standard deviations (s_ρ)											
1998	0.101*	0.100	0.107*	0.100	0.108*	0.102*	0.108*	0.103*	0.108*	0.103*	0.108*	0.103*
	0.032	0.032	0.030	0.024	0.027	0.019	0.026	0.018	0.025	0.017	0.024	0.017
1999	0.102*	0.100	0.107*	0.100	0.108*	0.102*	0.108*	0.103*	0.108*	0.103*	0.108*	0.103*
	0.032	0.032	0.030	0.024	0.027	0.019	0.026	0.018	0.025	0.017	0.024	0.017
2000	0.101*	0.098	0.106*	0.098	0.108*	0.100	0.107*	0.102*	0.107*	0.102*	0.107*	0.102*
	0.032	0.031	0.030	0.024	0.027	0.020	0.025	0.018	0.024	0.017	0.024	0.017
2001	0.101*	0.098	0.107*	0.098	0.108*	0.100	0.107*	0.102*	0.107*	0.102*	0.107*	0.102*
	0.032	0.031	0.030	0.024	0.027	0.019	0.025	0.018	0.024	0.017	0.024	0.017
2002	0.102*	0.098	0.107*	0.099	0.108*	0.101*	0.108*	0.102*	0.108*	0.103*	0.108*	0.103*
	0.032	0.031	0.030	0.024	0.027	0.020	0.025	0.018	0.024	0.017	0.024	0.017
2003	0.103*	0.098	0.107*	0.099	0.109*	0.101*	0.108*	0.103*	0.108*	0.103*	0.108*	0.103*
	0.033	0.032	0.031	0.024	0.029	0.019	0.026	0.018	0.025	0.017	0.024	0.017

Table 2.7: The bias of multiplier estimates based on the WIOD and DESTATIS data for Germany

Monte Carlo simulation procedures have become a 'go to' tool when dealing with the uncertainty issues in the input-output estimates. Its popularity originates in the feature that an analyst does not need to possess analytical results on the features of distributions of variables of interest. And, even though the existence of the random component in the input-output data is widely accepted (Quandt, 1958, 1959; Simonovits, 1975; West, 1986; Roland-Holst, 1989), there has been a debate about what distribution in perturbations and technical coefficients is reasonable to assume. If one is not comfortable making any assumptions on the shape of the distribution, mathematical theory of norms can be applied to square data systems to measure whether it is well-conditioned (Wolff, 2005). This way we can assess the global robustness of the outcomes of the input-output system to random perturbances.

Table 2.8 provides the results of the inverse condition numbers $\tau(\mathbf{B})$ for all datasets previously utilized in the Monte Carlo exercise. As a reminder, we follow Wolff (2005) in suggestion to use Germany's DESTATIS input-output data as an orienteer of a well-conditioned system. The chapter suggests the benchmark τ-measures for robust Leontief matrices in the range of 0.46 for the small-size input-output tables and in the range of 0.19 for the medium-size and larger input-output tables. In general, the smaller the value the more ill-conditioned the matrix. The closer the value τ approaches its natural upper bound of 1 the better conditioned it is considered to be. As can be seen in Table 2.8, nearly all $\tau(\mathbf{B})$ values neighbor the region of 0.4 regardless of the size of n. Among all, the IEF OKVED ($n = 43$) is the worst conditioned system with τ values varying between 0.107 and 0.28. Whereas, the best conditioned system is the WIOD (for both Russia and Germany) with the τ values ranging between 0.434 and 0.481.

Year	Rosstat (n=22)	IEF OKONh (n=25)	IEF OKVED (n=43)	IEF OKVED (n=22)	Rus WIOD (n=34)	Rus WIOD (n=22)	Rus Eora (n=47)	Rus Eora (n=22)	DESTATIS (n=67)	DESTATIS (n=22)	Ger WIOD (n=34)	Ger WIOD (n=22)
1998	0.164	0.362	0.107	0.218	0.439	0.473	0.435	0.447	0.374	0.432	0.455	0.439
1999	0.424	0.366	0.236	0.267	0.481	0.520	0.434	0.446	0.366	0.418	0.448	0.430
2000	0.421	0.362	0.218	0.278	0.479	0.519	0.424	0.436	0.373	0.406	0.449	0.455
2001	0.385	0.321	0.202	0.289	0.451	0.482	0.422	0.434	0.370	0.405	0.446	0.451
2002	0.383	0.318	0.247	0.269	0.445	0.473	0.420	0.432	0.367	0.401	0.441	0.450
2003	0.373	0.308	0.280	0.286	0.427	0.461	0.419	0.430	0.363	0.406	0.434	0.440
					The allocated condition rank							
	5	6	7		1		3		4		2	

Table 2.8: The inverse of condition number of a Leontief matrix B ($\tau(B)$)

If we aggregate the n dimension to $n = 22$ for all datasets, preserving the industry classification as portrayed in Appendix A, we can see in Table 2.8 that the aggregation procedure does not lead to any significant variation in the τ values and the condition rank for the datasets remains unchanged prior and post aggregation. Similarly, no effect is observed when we re-organize the data to different - the old (OKONh) and the new (OKVED) - industry classifications. All the datasets are analyzed in their original state as they are published in the databases, i.e. we do not apply currency conversions. As a robustness measure, even if we do convert Russian ROSSTAT, IEF OKONh, and IEF OKVED datasets from Russian rubles to US dollars, as expected, the condition states of the matrices remain unchanged.

Obviously, as $\tau(\mathbf{B}) \to 1$ the better conditioned the system is, the less sensitive the solution is with respect to the perturbation of the data. Even though the results in Table 2.8 suggest that the Russian input-output data is less robust to perturbations than the data from international sources (i.e., WIOD and Eora) or Germany (DESTATIS), the variation is rather small for most of the values. This is confirmed by observing the condition numbers $\kappa(\mathbf{B})$. Given the condition number can range between 1 (for an orthogonal matrix) and ∞ (for a singular matrix), one can see in Table 2.9 that the variation between the datasets is rather condensed.

Therefore, we conclude that Russian data passes the sensitivity test of being well-conditioned.

Year	Rosstat (n=22)	IEF OKONh (n=25)	IEF OKVED (n=43)	IEF OKVED (n=22)	Rus WIOD (n=34)	Rus WIOD (n=22)	Rus Eora (n=47)	Rus Eora (n=22)	DESTATIS (n=67)	DESTATIS (n=22)	Ger WIOD (n=34)	Ger WIOD (n=22)
1998	6.10	2.76	9.31	4.58	2.28	2.11	2.30	2.24	2.67	2.31	2.20	2.28
1999	2.36	2.73	4.24	3.75	2.08	1.92	2.30	2.24	2.73	2.39	2.23	2.33
2000	2.38	2.77	4.59	3.59	2.09	1.93	2.36	2.30	2.68	2.47	2.23	2.20
2001	2.60	3.11	4.95	3.46	2.22	2.08	2.37	2.31	2.70	2.47	2.24	2.22
2002	2.61	3.14	4.05	3.72	2.25	2.11	2.38	2.32	2.73	2.50	2.27	2.22
2003	2.68	3.25	3.57	3.49	2.34	2.17	2.39	2.32	2.75	2.46	2.30	2.27

Table 2.9: The condition number of a Leontief matrix B ($\kappa(B)$)

2.6 Conclusion

The question of uncertainty in the input-output modeling framework has been studied by many researchers since the input-output modeling framework has been developed[8]. In the original work Leontief (1936) acknowledges the conceptual opportunities of the input-output modeling framework. However, these opportunities rely on the 'immediate problem of the numerical accuracy of the individual entries'. But because it is impossible to possess the true coefficients, there is always a scope for uncertainty in the data, which can then propagate to the model outcomes. As a consequence, there is a myriad of possible sources of errors that can be found in the input-output modeling framework. To name a few, such sources include sampling errors, measurement errors, aggregation errors, omitted variable bias, reporting errors, deflation errors, balancing errors, industry/product classification errors. Therefore, when utilizing any numerical methods, it is important to know how reliable the model predictions are and how sensitive the algorithm is with respect to the inevitable noise in the input variables and system parameters.

In the research community there has been a concern over the quality of the Russian national data (Masakova, 2006; Ivanov, 2009; Voskoboynikov, 2012). In this chapter we conduct a comprehensive sensitivity analysis of the Russian national input-output data. We measure the error propagation capacity from the raw input-output data to the input-output multipliers. The multipliers are derived from the Russian official national input-output data (ROSSTAT) and the national input-output data published by the Institute of Economic Forecasting (IEF) within the Russian Academy of Sciences in the old, Soviet (OKONh) and the new, European-equivalent (OKVED) industry classifications. To assess robustness, we also utilize the German official input-output tables (DESTATIS) and the input-output tables for Russia and Germany published by internationally reputable research sources (WIOD and Eora).

Several approaches have gained popularity in measuring the sensitivity of the input-output system to random perturbances. These are deterministic error analysis, econometric and other (non-Bayesian) statistical approaches, probabilistic approach, full

[8]Leontief (1936); Quandt (1958, 1959); Stone (1961); Novak (1975); Simonovits (1975); West (1986); Roland-Holst (1989); Dietzenbacher (2006); Miller and Blair (2009).

probability density distribution approach, Monte Carlo analysis, Bayesian approach, and other techniques (ten Raa, 2017). In this chapter we concentrate on the Monte Carlo simulation approach and the mathematical norm approach.

The set up of the Monte Carlo simulation experiment follows closely Dietzenbacher (2006). We assume that the uncertainty originates in the raw input-output data, i.e. intermediate transactions and final demand. The perturbations are represented in the form of normally distributed, independent, stochastic errors with pre-defined variances. In the course of this chapter, we find, in line with Dietzenbacher (2006), that across all datasets the estimated multipliers are positively biased, but the actual size of the bias is minimal and is detected only in large samples of $K = \{1,000, 10,000\}$. Because the bias is so small, the derived input-output multipliers can be treated as unbiased when handled in economic analysis. The multipliers derived from the Russian national data exhibit on average greater stability than the multipliers derived from Eora or German data. The results hold across various robustness checks. We add to the existing literature on uncertainty treatment by showing that the results obtained in Dietzenbacher (2006) were not dependent on the country choice, i.e. also hold for detailed input-output data from another OECD country (Germany) and to detailed input-output data from Russia. Another important conclusion is that the findings in Dietzenbacher (2006) extend to Russia even though there are numerous differences to the Netherlands, Germany, and other OECD countries in the structure of the economy, institutional infrastructure, statistical guidelines, etc.

We utilize the theory of norms to assess the condition of the input-output system derived from different Russian data sources. We follow Wolff (2005) in this method and use DESTATIS data as a benchmark of a well-conditioned data system. The obtained condition results suggest that the Russian data is well-conditioned and is similar to German data in its ability to absorb random perturbations.

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Chapter 3

The Structure of the Russian Economy in Transition Period: an Input-Output Approach

3.1 Introduction

Being the largest and the oldest planned economy in transition, Russia attracted the interest of researchers for a long time[1]. In the past three decades, Russia has undergone dramatic structural and institutional changes. Among them are liberalization of price relations, relaxing terms and conditions for international trade, the privatization of state property, establishment of new financial, political, and national statistics systems (Ivanov, 2009; Shmelev, 2011). Despite an economic decline during the 1990s, Russia's economy was growing at almost 7% per annum beginning in 1999 claiming the 11th spot in the global GDP ranking by 2008 (Alexeev and Weber, 2013). However, the country continues to struggle from a myriad of issues inherited from the Soviet era. The objective of this analytical work is to study the production structure of the Russian economy, dedicating special attention to the estimation of inter-industrial linkages prior

[1] Leontief (1936); Doehrn and Heilemann (1996); Raiser Schaffer and Schuchhardt (2004); Lazarev and Gregory (2007); World Bank (2008); Shmelev (2011); Alexeev and Weber (2013).

and during the transition period covering 1980-2006.

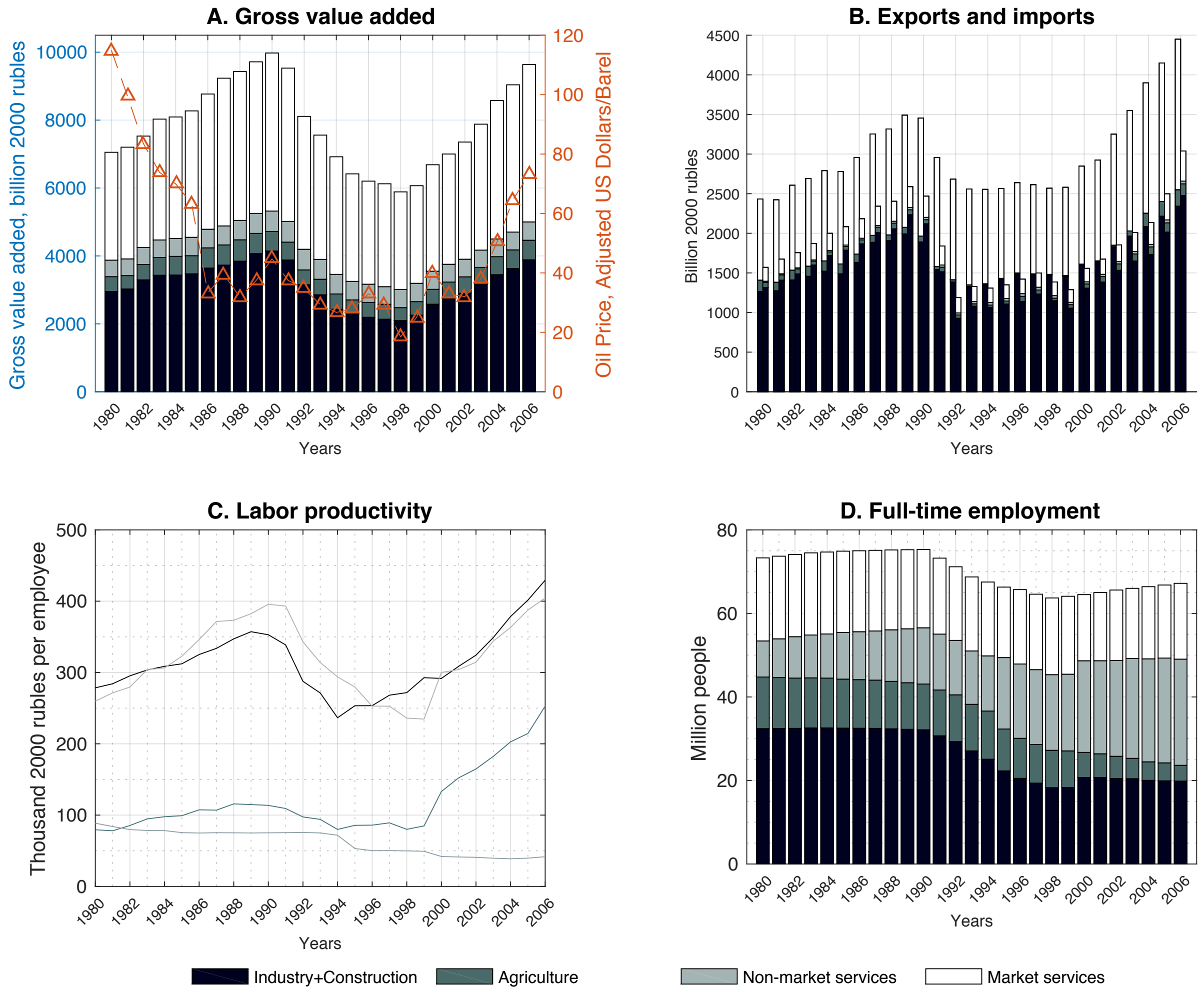
In order to study the production structure of the economy through measures of sectoral interrelations we utilize the input-output modeling framework. The input-output framework provides a statistically consistent and an analytically simple approach to measuring the economic impact of individual industries on the entire economy based on cross-checked, reliable data (Miller and Blair, 2009). Within the input-output modeling framework, impacts are studied via calculated input-output multipliers. The multipliers provide a robust way to study the structure and characteristics of the economy during the static time period for which the underlying input-output table is created. Via the notion of input-output multipliers it is analytically possible to disentangle the effects of an exogenous demand change in one industry on the entire economy. The captured effects quantify how much output (GDP, employment) is generated. The calculated effects can be ranked by order of magnitude to determine the performance of any sector in relation to other sectors within the economy to subsequently establish the relative importance of each industry. In addition to measuring the magnitude of the effects, the input-output modeling framework also describes their direction. In order to study the structure of the Russian economy we calculate and evaluate the following input-output multipliers: net output and value added, Type I and Type II output (production), GDP (value added-output), and employment (employment-output).

Overall, all throughout the studied period of 1980-2006 we can see that the production structure of the Russian economy (characterized by the strength of the inter-industrial linkages) remains energy-intensive. However, there is a shift in the form of energy-intensive production from specialization in manufacturing during the Soviet period towards specialization in production of raw natural resources such as oil and (ferrous and non-ferrous) metals in the post-Soviet years. In addition, starting from the late 1990s, the strength of the inter-industrial linkages of service sectors, especially market services, grows. Through the decomposition of the final demand into domestic and foreign, we further observe that the majority of activity stimulated by domestic final demand falls on industries such as 'Construction', 'Food', 'Agriculture', 'Transportation' and services. Whereas the activity in sectors such as 'Oil extraction', 'Oil processing', 'Non-ferrous metals', 'Ferrous metals' is predominantly driven by foreign final demand.

The remainder of the chapter is structured in the following way. Section 3.2 provides stylized facts about the socio-economic state of Russia during the period of 1980-2006. Section 3.3 provides a comprehensive coverage of the data requirements in order to conduct the input-output analysis starting with a brief historical review extending to a detailed description of the steps in construction of a symmetric input-output table concluding with the specificities of the Russian national statistics. Section 3.4 delivers a detailed review of the input-output methodology with assumptions and limitations which provides the necessary background to analytically follow the discussion of the derived multiplier estimates. Section 3.5 presents a detailed discussion of the results. And, Section 3.6 summarizes the main findings based on the discussion of the various multiplier measures regarding the production structure of the Russian economy and its evolution.

3.2 Stylized facts

Russia is the largest economy in transition studying the development of which presents a unique opportunity to better understand the path a socialist country takes while transitioning towards a market economy. Up to the point of dissolution of the Soviet Union, Russia followed industrialization process specific to socialist economies, i.e. initial rapid industrialization with strong collectivized agricultural policy where excess labor was driven and kept in the industry. Due to the centrally planned nature of the economy, there were no sectoral structural adjustments in Russia that normally occur in the market economies when the forces such as differential productivity growth, sectoral relocation of labor, and consumer preference effects play deterministic roles. As a consequence, at the start of the transition Russia had a larger share of employment in industry and a lower share of employment in agriculture compared to market economies with similar GDP per capita levels (Raiser Schaffer and Schuchhardt, 2004). The market service sectors were underdeveloped. At the start of the transition, there was an expectation that the Russian economy was going to progress along common development path, i.e. the contraction of the stagnating secondary (industry) sector while freeing up the surplus labor, and the development of the tertiary (market services) sector [2].



Source: GVA, exports, imports, output data - Russian input-output tables, oil prices - IMF database, labor data - ROSSTAT database.

Figure 3.1: Macroeconomic indicators 1980-2006: broad sectors

Figure 3.1 provides some insight into the state of the Russian economy during the period 1980-2006. The economy is divided into four broad sectors: industry, agriculture, non-market services, and market services. Figure 3.1.A describes the gross value added generated by the economy. During the Soviet episode of our study period the economy grew by 41% with an annual average of 4%. The sectoral share in value added throughout the 1980s remained approximately unchanged where approximately 40% of value was generated in each the industry and market services. The majority of growth

[2]Doehrn and Heilemann (1996); Raiser Schaffer and Schuchhardt (2004); Lazarev and Gregory (2007); World Bank (2008).

during the Soviet period happened in the years of Perestroika (1985-1991). During Perestroika a series of economic reforms have been initiated that have started a gradual process of economy's restructuring while still under the rule of the Communist party - a period of Market Socialism. One of the main characteristics of this period was trade liberalisation, where the value added originated in the trade sector increased by over 50% between the years 1985 and 1991. During Perestroika total exports increased by 24% and total imports increased by 19%. During the Soviet episode and afterwards Russian exports consisted predominantly of primary resources (oil, gas, ferrous and non-ferrous metals) and machinery. The imports, on the other hand, were largely comprised of products of machinery, textile, and food industries. Figure 3.1.B also shows that a large share of exports originates in market services, i.e. in trade industry. However, without tracking the backward linkages it is incomprehensible to immediate pin down sectors which drive the activity in trade services. Later in this chapter, with the use of input-output multipliers we will disentangle these inter-dependencies.

Since the mid 1980s the economy appears to start having a positive correlation with the oil price, perhaps driven by openness to trade. Historically, the Russian federal budget had high reliance on sales of oil and gas to both domestic and international markets - between 40 and 50% (Minfin, 2019). Per estimations of Kwon (2003), an increase in the price of crude by 1 US dollar per barrel is expected to raise the Russian federal budget revenue by 0.35% of GDP. According to official statistics, approximately 80% of exports were natural resources, where a half of them was from the oil and gas sectors. With some insignificant deviations, this number is persistent across the years.

During the 1990s the Russian economy underwent fundamental political and economic changes. This chapter is dedicated to estimation of the changes in the production structure of the Russian economy, and we will discuss the topic especially pertaining this decade in the next sections. For now, it is important to note the overall decline during the 1990s. During the first five years following the dissolution of the Soviet union the economy was contracting with an average annual rate of 8% totaling 35% decline in between the years of 1991 and 1996. In 1998 the economy defaulted on its domestic debt. Despite the common expectations of long recovery, the Russian economy started showing signs of improvement already in the following year. There is a number of factors that contributed to the quick recovery: increased carbon prices that started to increase since 1999, the underutilized capacity due to the long-standing output decline but not employment, the import substitution effects due to rapid real exchange rate devaluation following the 1998 crisis, growing real wages more rapidly than productivity leading to boosted domestic consumption, and domestic policy on hard budget constraints and energy subsidies (World Bank, 2003a,b). From 1999 until 2006 the economy grew by approximately 6% annually, in total by 59%.

The general evolution of labor productivity and employment shares can be seen in Figure 3.1.C and D. Once the Soviet union collapsed, there can be noticed the process of sectoral labor reallocation where the surplus labor was now moving from industry to services. The employment share occupied in non-market services, i.e. education, health care, defense, housing services, was growing faster compared to the share in market services. Raiser Schaffer and Schuchhardt (2004) find this development phenomenon to be common among socialist economies in transition. The shares of employment in industry and agriculture fell compared to the Soviet period. In 2006 only 6% of the labor force were occupied in agricultural sector, 30% in industry, 38% in non-market services, and 27% in market services. The sectoral reallocation represented in the labor data indicates that the direction of the structural change in Russia moves along the expected development path - a contraction of the industrial sector and an expansion of services. However, further improvement is needed. During the economic hardships of the 1990s the Russian government in order to keep the general unemployment figure down was creating low level jobs (cleaners, janitors, security guards) in the public sector (ROSSTAT, 2003, 2007). The labor in their prime working age occupied in these low level jobs needs to be re-specialized which could lead to increased labor productivity and economic growth.

3.3 Data

3.3.1 A symmetric input-output table

The input-output modeling framework has become an important tool for socio-economic planning and policy analysis. Hence, special attention is dedicated to the collection of statistically robust data that can be utilized for such analytical purposes. The data baseline of the input-output modeling framework is a symmetric input-output table.

The input-output theoretical framework in its modern form was developed by Wassily Leontief in the beginning of 20th century and published in 1936 on the example of the US interindustrial transactions tables (Leontief, 1936). The initial idea of productive interdependencies though can be traced back to Sir William Petty in the mid 17th century to his formulation of the 'circular flow' of income in an economy. On its basis, in 1758 the French economist Francois Quesnay made the first attempt to depict the 'circular flow' of income between economic sectors in the diagrammic representation that he called 'Tableau Economique' (Quesnay, 1759). Some academics, including Schumpeter (1954, p. 217), credit Quesnay and his 'Tableau Economique' as the first explicit formulation of the general equilibrium theory. Leontief (1941) himself writes that the framework 'may be best described as an attempt to construct a Tableau Economique of the United States.' Conceptually speaking, Leontief's input-output framework goes beyond a graphical representation of the sectoral interdependencies, it provides an empirical analytical tool for the short-run economic analysis and forecasting.

Even though the framework was developed by Leontief, it was not until Sir Richard Stone that it received international acceptance and became integrated with the system of national accounts (SNA) (Stone, 1961). Frequently the data needed to construct the symmetric input-output table is derived from a larger collection of socio-economic data. These data form the system of national accounts which is periodically collected by means of a census or other survey methods (SNA, 1993; UN, 2018). Historically, the primary goal of a national census has been to estimate a nation's GDP, but it also provides a convenient basis for construction of interindustrial flows, which are subsequently used to develop supply and use and then symmetric input-output tables

(Miller and Blair, 2009). The construction of input-output tables by survey-based means is both complex and expensive. For this reason the survey-based tables are published approximately every five years and are called the base year or benchmark input-output tables (Miller and Blair, 2009). In the course of conducting a survey, the data is collected from thousands of business establishments to be subsequently aggregated to form a specific sector of an economy. However, it is common that a given firm produces more than a single kind of product or service which consequently gets attributed to different sectors. The intermediate tables between two successive base years are often constructed with the use of non-survey methods, i.e. bi-proportional techniques (RAS), maximum entropy methods, or Bayesian methods. For detailed review of these methods an interested reader should consult Miller and Blair (2009) and ten Raa (2017).

When discussing the construction of a symmetric input-output table, it is important to mention how the underlying commodities and industries are being handled. There are two key tables that are utilized when building an input-output table - the use and supply tables. The use table provides a record on the consumption of commodities by industries or by final demand categories, where the consumed commodities appears in the rows and the consuming sectors and final demand groups appear in the columns. The supply table depicts the output mix of sectors, where the rows represent produced commodities and the columns represent the producing sectors and imports. Hence, the intermediate transactions part of the use and supply tables is of the dimension commodity-by-industry. In contrast to the supply table where the imports are recorded as a separate column, the use table may not represent imported transactions as a separate matrix. Hence, the use table may represent either consumption of total commodities within the economy or only the consumption of domestically produced products. In the latter case the use table will also be separated into a use table of imports which provides a record on the consumption of imported commodities and services by products and by industries and final demand categories (ESA, 1995).

The differing representation of imports within the use network is attributed to a varying assumption of imports production technology. In the case when the imports are presented in combination with domestic commodities as total consumed goods and services, the imports are assumed to have similar production technology to the home country. These imports are called competitive imports. In the case when the consumed goods and services are recorded as separate entities, the underlying production technology is assumed to be different between the domestic production and those of imports. These imports are called non-competitive imports. The assumption of competitive versus non-competitive imports subsequently is transferred to an input-output table. Arguably, it is debatable whether it is sensible to assume similar production technology for commodities produced in different countries, but there is no one correct way to approach this decision (SNA, 1993; Miller and Blair, 2009). Whether or not to assume similar production technology is decided by a statistical institution that constructs an input-output table. For example, most of the OECD countries utilize the non-competitive imports assumption, while Russia, China and the USA use the competitive imports assumption (Su and Ang, 2013). We will recommence the discussion on imports in Section 3.4.

The construction of a symmetric input-output table involves a sequence of analytical procedures that include transformation of the information presented in the supply and use tables into a single square table (ESA, 1995). The transformation will require a set of assumptions and adjustments. Before any transformation takes place, the use table needs to be converted from purchasers' prices to basic prices. It is a norm that the valuation within a symmetric input-output table is at basic prices. As the System of National Accounts (SNA, 1993) defines it, 'the basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale; it excludes any transport charges invoiced separately by the producer.' The supply table being the record of produced resources in the economy is already in basic prices with included extension to purchasers' prices via included sum of trade margins, transport margins and taxes minus subsidies on products. To arrive at basic prices, prices are transformed as follows: Purchasers' prices - trade margins - transport margins (- non-deductive VAT) = Producers' prices - taxes on products (excluding VAT) + subsidies on products = Basic prices.

Once the supply and use tables are transferred to basic prices, the format of a table is chosen. Due to a commodity-by-industry dimension of the supply and use tables, a symmetric input-output table can be represented in either a product-by-product (commodity-by-commodity) or an industry-by-industry form. Before discussing the choice between these two representations, it is beneficial to touch upon the industry and product classifications. At present, most of the countries follow one version or another of the UN industry and product classification systems called the International Standard Industrial Classification (ISIC) and the Central Product Classification (CPC). On their basis in Europe the Eurostat developed the Statistical Classification of Economic Activities in the European Community (NACE) for industry classification and the Classification of Product by Activity (CPA) for product classification. In Russia the industrial and product classifications until the mid 2000 were following the old Soviet accounting guidelines and subsequently made a transition to the OKVED industry and OKPD product classifications that are harmonized with international and European classification counterparts. We will provide a deeper discussion on the evolution of the industry and product classifications in Russia in the next subsection.

In order to transform the supply and use tables at basic prices into a symmetric input-output table at basic prices the preference for treatment of secondary products should be chosen. According to UN (2018) and Eurostat (2008), there are 4 standard transformation models. Each model is based on a separate set of assumptions regarding the treatment of secondary products and has a different mathematical formulation. Covering the formulation of these models is beyond the scope of this chapter. An interested reader is directed to UN (2018) and Eurostat (2008) for mathematical coverage. Two models have a product-by-product dimension and rely on the choice of production technology assumptions and two industry-by-industry models are based on the sales structure assumptions. When constructing a product-by-product input-output table, a choice between product technology and industry technology needs to be made. Under the product technology assumption the intermediate transactions depict the commodities are required to produce other commodities. A commodity has the same input structure irrespective of the industry it is produced by. Therefore, from the table following the product technology assumption it is impossible to identify the industry from which the commodities originated. On the other hand, the industry technology assumption describes the production relationship between the sectors of the economy, in which each row describes the sectoral supply of output and each column describes the sectoral input demand. In this case, each industry has its own specific way of production - irrespective of its product mix. When constructing an industry-by-industry input-output table, the choice between fixed industry or product sales structure should be made. Under the fixed industry sales structure each industry is assumed to have its own sales structure, irrespective of its product mix. Whereas, under the fixed product sales structure each product has its own specific sales structure, irrespective of the industry where it is produced. Eurostat (2008, page 301) suggest to base the selection of the appropriate size of the input-output table (product-by-product or industry-by-industry) on the objectives of economic analysis. The industry-by-industry input-output tables are closer to statistical sources and actual market transactions, whereas, the product-by-product input-output tables are more homogenous in terms of cost structures and production activities. The Russian input-output tables are set up as product-by-product tables.

Because an input-output table can be seen as a static general equilibrium of an economy, certain balancing criteria need to be met (Miller and Blair, 2009):

- Total gross output = total inputs
- Total final demand = total inputs of primary factors
- Total intermediate demand output = total intermediate input
- Total input = total output for each product/industry

The general structure of a symmetric input-output table under the competitive imports assumption is represented in Table 3.1.

The first quadrant is an $n \times n$ matrix of the intermediate transactions under the competitive imports assumption, hereafter abbreviated as $\mathbf{Z}$, is a sum of domestic ($\mathbf{Z_d}$) and imported ($\mathbf{Z_i}$) intermediate transactions. The second quadrant is an $n \times m$ matrix of final demand by category $\mathbf{y_f} + \mathbf{y_e} = (\mathbf{y_d} + \mathbf{y_i}) + \mathbf{y_e}$, where $\mathbf{y_f}$ is a summation of domestic and imported final demand for m categories, $\mathbf{y_e}$ is a $n \times 1$ vector of exports. In order to get the total final demand at basic prices $\mathbf{y} = \mathbf{y_f} + \mathbf{y_e} - \mathbf{y_m}$. The third quadrant is a $k \times n$ matrix matrix of value added by category. The vertical sum of all

<table>
<tr><th></th><th>Industries/ Products</th><th>Final household expenditure</th><th>Gross capital formation</th><th>Exports</th><th>Imports</th><th>Total output at basic prices</th></tr>
<tr><td>Industries/ Products</td><td>Intermediate transactions at basic prices

$Z = Z_d + Z_i$
(nxn)</td><td colspan="3">Domestic final demand at basic prices

$y_f + y_e$
(nxm)</td><td>y_i

(nx1)</td><td>x

(nx1)</td></tr>
<tr><td>Taxes less subsidies on products</td><td></td><td colspan="5" rowspan="3"></td></tr>
<tr><td>Compensation of employees

Other net taxes on production

Consumption of fixed capital

Net operating surplus</td><td>Gross value added at basic prices

v′
(kxn)</td></tr>
<tr><td>Total input at basic prices</td><td>x′</td></tr>
</table>

Table 3.1: A structure of a symmetric input-output table (competitive imports assumption)

value added categories provides the gross value added at basic prices ($\mathbf{v}'$). The fourth quadrant is usually left empty. In more developed models, the entries in this quadrant form the Social Accounting Matrix, or SAM. As can be seen from Table 3.1, it connects final expenditure accounts with value added and taxes. These are so-called non-market or 'social' transfers, which include gifts, savings, taxes by households, surpluses and deficits of governments and their payments to households and intergovernmental transfers (Miller and Blair, 2009). The quadrant also typically includes purchases by final demand accounts from industries outside the region. The total output by industry/product is found through summation across all the row entries of the intermediate output and final output. The total input by industry/product is calculated by summing down the columns of the intermediate inputs and the value added entries.

3.3.2 Russian industry/product classification evolution

In Russia the Russian Federal State Statistics Service (ROSSTAT) is the head statistical institution that is responsible for collection, processing and publishing of socio-economic data as well as for standardization of the classification nomenclature. The SNA (1993) was introduced in Russia since the beginning of transition in 1991, substituting for the old Soviet national accounting principles called the Material Product System (MPS). Due to a rapid marketization, the process of transition to new accounting principles was slow-moving and some parts of the MPS have survived in the system of national statistics to this day.

The co-existence of the MPS and SNA standards during the period of transition is unavoidable. It is important to take into account the gradual institutional evolution of the economy, i.e. the privatization of the state property, the emergence of new types of institutional units, as well as the evolvement of new market principles, i.e. the introduction of the capital accounting standards and price mechanisms. These changes were affecting not only the methodological evolvement but also the data collecting processes. The co-existence of the principles created conceptual inconsistencies between different blocks of the Russian statistical system, especially when it came to measuring national output and growth rates. Often the MPS principles produced exaggerated growth figures (Bergson, 1991; Masakova, 2006; Ivanov, 2009). Firstly, the problem of proper estimation is created due to the narrow definition of production structure within the planned economy (Masakova, 2006). The non-material services, i.e. education, healthcare, culture, housing, public administration and defense, financial services, etc, were not accounted for. Secondly, the underdeveloped price accounting led to some products and industries having disproportionately large weight relative to other products. As Ivanov (2009) notes, the principle 'a potato is a potato' was consistently used, which means in the comparison of prices of representative items, a distinction between different sub-types of a product were not made. Thirdly, a considerable problem is that the consumer price indices (CPIs) were not consistent with international standards. The lack of experience in conducting household and labor surveys and of preparing price statistics in periods characterized by high inflation, mass reallocations of capital and labor force led to data inconsistencies over the years of transition. Fourthly, a lack of experience in the organization of statistics, especially concerning conducting the survey-type data and its processing, led to incorrect aggregates. Finally, there was a large gap in the institutional organization with remaining direct government control over activities of the statistical services. The main differences between the MPS and the SNA that caused inconsistencies in estimations are summarized in Appendix B, Table B.1. The table on concordance of industries under the SNA and the MPS classifications is available in Appendix A, Table A.3. However, as Bergson (1991) notes when analyzing the sources of differences in growth accounting when using the Soviet and western GDP accounting principles and then Ivanov (2009) confirms using the transition data, the main source of distortion in growth estimates came not from the methodological differences in concepts of economic production. It originated 'due to factors that are generally characteristic of national accounting', e.g. invalid deflators, incomplete coverage of the non-observed economy, and errors in and missing data. In addition, only simplified indicators of labor productivity were used, which did not account for changes in the structure of the labor force. No attempts were made to measure productivity (e.g. capital, labor, multifactor). In general, the income and capital were not adequately valued throughout the transition period, e.g. simplified treatment of capital formation and depreciation/consumption of various forms of capital, and additionally, some types of income were not identified for a long time (Voskoboynikov, 2012).

As a consequence, the industry and product classifications were changed four times in the period of 1990-2009. The annual input-output tables of 1998-2003 follow the MPS industrial classification (OKONKh, 'Otraslevaya Klassifikaciya Narodnogo Khozyajstva') and All-Russian Product Classification (OKP, 'Obscherossiiskyi klassifikator produkcii'). In 2003 the OKONh industrial classification was replaced by a new industrial classification (OKVED, 'Obschcherossiiskyi Klassifikator Vidov Ekonomicheskoi Deyatel'nosti'), which is consistent up to four digits with the Statistical Classification of Economic Activities in the European Community (NACE Rev.1), but still follows the OKP on the product level. The comparison of the OKONh and the OKVED/NACE industry classifications is available in Appendix A, Table A.3. Such inconsistency made the derivation of the annual symmetric input-output tables impossible, keeping the base year of 1995 (which is unavailable). The ROSSTAT offers the input-output tables for 1998-2003 in basic current prices of thousands of rubles and has a dimension of product-by-product (22×22). Due to conceptual inconsistency in the product/industry classification since 2003 there is a break in the input-output time series. The ROSSTAT published the supply and use tables for years 2004-2006 but they follow the inconsistent classification. The work on development of the new base input-output tables for 2011 started in 2012. They are based on the OKVED 2007 (or NACE 1.1) and the new OKPD ('produkciya po vidam ekonomicheskoi deyatel'nosti') product classification, which is harmonized with the European counterpart the Classification of Product by Activity (CPA). Following the creation of the 2011 base input-output tables, the new base tables will be created every five years [3].

3.3.3 Data description

The ROSSTAT offers relatively short input-output time series of 6 years covering 1998-2003 with further 3 years of available supply and use tables covering 2004-2006. However, these supply and use tables have contradicting underlying industry and product classifications where the industry classification is still the old Soviet OKONh classification but the product classification is new updated to international standards OKPD. Due to the lack of detailed product level data, it is not possible to consistently reformulate either the supply and use or the input-output tables to OKVED/NACE standards.

To address the problem of limited size of the time series, several research institutes attempted to create their own systems of input-output tables. One such development is based on efforts of the Institute of Economic Forecasting (IEF), a branch of the Russian Academy of Sciences (RAS). The institute has developed input-output tables in basic current prices and basic constant prices (with 2000 as a base year) for the period of 1980-2006 consistent with the OKONh/OKP classification and in basic current prices and basic constant prices (with 2010 as a base year) for the period of 1980-2013 consistent with the OKVED 2007/OKPD classification (IEF, `macroforecast.ru`). In fulfillment of the data requirements and for balancing of the tables, the institute obtains

[3] The new base year input-output table for 2011 is published on the ROSSTAT website (`www.gks.ru`) in July 2018, after this chapter is concluded. The table has dimension product-by-product (126x126).

information from the ROSSTAT and partially through its own survey methods with subsequent utilization of the in-house algorithm. Thereby, the input-output data is expected to capture the timely change in production technology in the covered period. It is an attractive source of data as it offers nationally generated input-output time series by an internationally reputable statistical source.

In studies that have an objective to estimate structural (technological) change of an economy over the years, such as Carter (1970), it is necessary to use the input-output tables at constant prices (Miller and Blair, 2009). Up to the mid-2000s the Russian input-output tables were published under the Soviet classification, to preserve the authenticity of the industry classification during the study period and to avoid additional uncertainty that could have been transcribed when the IEF derived the new dataset based on the OKVED classification, we choose to use the input-output tables published by the IEF in constant prices following the OKONh classification.

Therefore, in this chapter we use the input-output data covering 1980-2006 in the OKONh industry classification in constant year 2000 prices. The data has sectoral disaggregation of 25 ($n = 25$) and is denominated in rubles. The full list of industries and sub-industries in the OKONh classification is available in Appendix B, Table B.2. The industry list within the IEF input-output dataset is presented in Appendix B, Table B.3. The full-time employment figures by kind of economic activity are obtained from the publications 'The National Economy of the USSR', 'The Russian Statistical Yearbook', and 'Work and employment' (ROSSTAT, 1990, 1995, 2000, 2003, 2007).

3.4 Methodology

The present section provides an overview of the demand-driven input-output modeling framework and its assumptions. The input-output analysis is based on a system of linear equations that describe the distribution of an industry's product throughout the economy (Miller and Blair, 2009). The importance and convenience of the input-output analysis to reflect inter-industrial flows is acknowledged by many national statistical agencies in the form of regularly assembled symmetric input-output tables and derived on their basis input-output multipliers (UN, 2018).

The input-output framework depicts the composition of economic activity in terms of purchases and sales between industries, on which a given economy is disaggregated according to a compliant industry classification, and the final expenditure group to fulfill intermediate or final demand. These recorded monetary transactions (transfer payments) describe a set of inter-relationships which analytically can be represented in the form of a set of linear equations. A single equation, therefore, describes the distribution of a single industry's output throughout the economy.

The input-output framework relies on a set of assumptions. In the input-output framework both supply and demand in the given base year realize at a given set of relative prices which given the fixed-proportions production function (Leontief production function) allows to interpret the technology, or a relative mix of inputs to a unit of output, as an average relationship applied that year.

One of the main assumptions of the demand-driven input-output framework is the constant returns to scale which postulates that in order to double the output, it is enough to double the inputs to production according to pre-determined proportion (input 1/input 2). The fixed proportion nature of the input requirements points at the fact that the mix of inputs needed to produce a unit of output for this industry is assumed to be constant regardless of the amount of the total output produced. Therefore, the amount of purchased inputs is determined solely by the desired level of output within a particular industry. It means that the input-output model has no consideration for possible changes in input prices, production technology or the effects of economies of scale on production level. It is assumes that the sectors can purchase as many inputs to production as needed without facing higher prices. Also, under the demand-driven input-output modeling framework the supply is assumed to be perfectly elastic and infinite. When there is an exogenous shock to the final demand, it is assumed that there is enough of factors of production, resources, and production capacity to meet this increased demand.

Another limitation of the input-output modeling framework arises from the fact that in practice there is frequently a substantial time lag between gathering of the data and availability of the input-output tables. The production technology represented within the input-output framework captures the state of the production capability of the economy at the time of the base year. The interim annual input-output tables are derived using specific algorithms, i.e. maximum entropy method, RAS balancing algorithm or Bayesian techniques, from the available macroeconomic aggregates and usually assume the state of the production technology of the base year. Even though the assumption of the static production technology is arguably restrictive, it is consistent across time (Carter, 1970). For example, an electricity generation plant lasts 30 to 50 years and variations from year to year are small. Carter (1970) finds that even in the dynamic economy, such as the US economy, the total intermediate output in the economy varied only by 3.8% over the span of 22 years. Therefore, arguably, the assumption of a static production technology over a reasonably short period of time might be justified. In case of the market economy, it can be explained by the fact that it takes time for the relative prices to exhibit notable change. And, in case of the socialist economy, the central planner assumes rigidity of the production structure, static technical coefficients.

Additionally, in order to utilize the input-output tables as the data source we need to accept an additional limitation brought by the inherent structure of the input-output table. Hence, though an industry may use a composition of commodities as inputs, its output is not mixed, i.e. each industry is identified by the commodity it produces.

3.4.1 Demand-driven input-output model

The basic demand-driven input-output model is defined as a fixed price static equilibrium model that describes interdependencies between industries according to the fixed-proportions production function. The starting point of the input-output methodology is an input-output table. The input-output table represents a composition of economic activities in terms of intermediate and final purchases and sales between industries and final consumers in the given time period, e.g. a year (SNA, 1993; ESA, 1995; UN, 2018). The table records inter-industrial transactions via disaggregation of the economic activity into n sectors.

Table 3.2 provides a representation of the symmetric input-output table constructed under the competitive imports assumption. Up until 2018, the Russian input-output

	Intermediate consumption	Final demands	Imports	Total output
Intermediate inputs	$\mathbf{Z} = \mathbf{Z_d} + \mathbf{Z_i}$	$\mathbf{y_f} + \mathbf{y_e} = (\mathbf{y_d} + \mathbf{y_i}) + \mathbf{y_e}$	$-\mathbf{y_m}$	$\mathbf{x}$
Value added	$\mathbf{v}'$			
Total inputs	$\mathbf{x}'$			

Table 3.2: Structure of the input-output table with competitive imports assumption

tables were published in this format. The intermediate transactions matrix $\mathbf{Z} = [z_{ij}]$, $i, j = 1, ..., n$ of the table is constructed using specific mix of inputs described by the Leontief production function. The production process of each sector within the matrix $\mathbf{Z}$ describes in terms of monetary value how much inputs it needs from other sectors to produce its output. Within the Russian input-output framework, each commodity is produced in its own specific way, irrespective of the sector where it is produced. Therefore, the input-output table reflects commodity-based production technology. Because all entries in the symmetric input-output table are essentially price multiplied by quantity, it is important to note that once the prices are accounted for they do not change. In studies that have an objective to estimate structural (technological) change of the economy over the years, such as Carter (1970), it is necessary to use the input-output tables at constant prices (Miller and Blair, 2009). Each column j of the input-output table represents the supply side of the economy, where each individual sector acts as a producer acquiring production inputs from row sectors i. Each row i describes distribution of a producer's output to fulfill intermediate demand z_{ij} and final demand y_i of each sector in the economy. The final demand groups y_i, $i = 1, ..., m$ conventionally consist of household consumption, government consumption, capital formation, changes in stocks, and net exports. In other words, the rows of the input-output table represent the demand side of the economy. Due to the general equilibrium nature of the input-output model, we expect supply for each sector x_j to be equal demand for each sector x_i.

Table 3.2 describes interindustrial transactions under the competitive imports assumption. This assumption postulates that the imported products (if they have a domestic equivalent) are produced using similar technology. The United States and China utilize this assumption when constructing their input-output tables (Su and

Ang, 2013). The consequence of this assumption is that within the input-output table the intermediate transactions ($\mathbf{Z}$) are represented as a sum of combined domestic ($\mathbf{Z_d}$) and imported ($\mathbf{Z_i}$) intermediate transactions as well as the final demand section ($\mathbf{y_f}$) is represented as a sum of domestic ($\mathbf{y_d}$) and imported ($\mathbf{y_i}$) final demand. Thereby, if an analyst seeks to study an impact the domestic production has e.g. on emission generation, it is advised to separate the imported and domestic shares of intermediate transactions and final demand to properly quantify the effect (Su and Ang, 2013). We follow Su et al. (2010) and Pan et al. (2008) as the methodological guide for such extraction. This technique assumes import similarity, i.e., for each sector product the mix of imported and domestically produced commodities is the same across all consuming sectors and domestic final demand categories for that product, but varies among different products. This method also implicitly assumes no direct consumption of imports by final demand. Though this formulation for imports extraction is a simplified view of the reality, it is a standard technique in the literature driven by the limited available data[4].

The following formulas are used to extract the imports technical coefficients and final demand vector:

$$s_i = \frac{y_{m,i}}{x_i + y_{m,i} - y_{e,i}}, \quad \mathbf{A_i} = \hat{\mathbf{s}} * \mathbf{A}, \quad \mathbf{y_i} = \hat{\mathbf{s}} * \mathbf{y_f}, \tag{3.1}$$

where s_i is the share of imports in the supply of products and services to each sector i, $y_{m,i}$ is the amount of domestic imports for sector i, $y_{e,i}$ is the amount of domestic exports for sector i, $\mathbf{A_i}$ is the imported technology matrix, and $\mathbf{y_i}$ is the vector of the direct imports for domestic consumption. The 'hat' symbol signifies diagonalization. Thereby, the domestic technical coefficients and domestic final demand are obtained as $\mathbf{A_d} = (\mathbf{I} - \hat{\mathbf{s}})\mathbf{A}$ and $\mathbf{y_d} = (\mathbf{I} - \hat{\mathbf{s}})\mathbf{y_f}$.

In order to mathematically formulate the demand-driven input-output model, we read along each row of Table 3.2. Reading along each row, the sum of elements z_{ij} of matrix $\mathbf{Z}$ that represent intermediate deliveries for production from industry i to industry j[5] and the sum of elements y_{im} of matrix $\mathbf{y}$ that describes the final deliveries

[4]Pan et al. (2008); Weber et al. (2008); Miller and Blair (2009); Su et al. (2010).

[5]Within the symmetric input-output framework, it is normally assumed that each industry produces a single product of output.

from industry i to a category of final demand m yield a vector of total output for each sector within the economy x_i. Hence, the demand-driven input-output model can be written as a system of n simultaneous equations:

$$
\begin{aligned}
x_1 &= z_{11} + z_{12} + \ldots + z_{1n} + y_{11} + ... + y_{1m} \\
&\vdots \\
x_i &= z_{i1} + z_{i2} + \ldots + z_{in} + y_{i1} + ... + y_{im} \\
&\vdots \\
x_n &= z_{n1} + z_{n2} + \ldots + z_{nn} + y_{n1} + ... + y_{nm}
\end{aligned}
\tag{3.2}
$$

Next, we define a matrix of technical coefficients $\mathbf{A}$ with elements $a_{ij} = z_{ij}/x_j$ which relate the intermediate input requirements from sector i per unit of industry j's total output. Recall from the previous discussion on the input-output framework's limitations that one of the most fundamental assumptions is that the amount of inter-industrial flows from i to j entirely depends on the desired level of total output of industry j. Hence, ignoring for the moment the primary factor inputs, the Leontief production function can be formulated as $x_j = \min\left(\frac{z_{1j}}{a_{1j}}, \ldots, \frac{z_{nj}}{a_{nj}}\right)$ (Miller and Blair, 2009). The technical coefficients a_{ij} measure the fixed relationships between sector j's output and its production inputs i.

After we define the technical coefficients a_{ij}, we can re-write the demand-driven input-output model depicted in equation 3.2 as follows:

$$
\begin{aligned}
x_1 &= a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + y_{11} + \ldots + y_{1m} \\
&\vdots \\
x_i &= a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n + y_{i1} + \ldots + y_{im} \\
&\vdots \\
x_n &= a_{n1}x_1 + a_{n2}x_2 + \ldots + a_{nn}x_n + y_{n1} + \ldots + y_{nm}
\end{aligned}
\tag{3.3}
$$

The main research question that is studied with utilization of the demand-driven input-output models is of the type 'how much e.g. output, employment, value added, emissions are generated within each sector of the economy in response to an exogenous unit change in final demand?' It means that n unknown variables x_i as described by equation 3.3 will need to be determined. Given the static nature of the technical coefficients, once the proportion of inputs to output is determined it remains constant. The only variables that have an effect on the amount of output produced are the elements of final demand y_i. If we, for simplicity of representation, sum through categories of final demand, $\sum_m y_{im}$, re-arrange equation 3.3 so that we have all exogenous variables y_i on one side and endogenous variables x_i and a_{ij} on an opposing side, and write it in the matrix notation, we have the following:

$$\begin{bmatrix} (1-a_{11}) & -a_{12} & \cdots & -a_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ -a_{i1} & (1-a_{i2}) & \cdots & -a_{in} \\ \vdots & \vdots & \ddots & \vdots \\ -a_{n1} & -a_{n2} & \cdots & (1-a_{nn}) \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_i \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} y_1 \\ \vdots \\ y_i \\ \vdots \\ y_n \end{bmatrix} \tag{3.4}$$

In reduced matrix form, the same relationship can be written as:

$$(\mathbf{I} - \mathbf{A})\mathbf{x} = \mathbf{y} \tag{3.5}$$

where $\mathbf{I}$ is an $n \times n$ identity matrix.

Within the input-output framework the matrix $(\mathbf{I} - \mathbf{A})$ is called the production technology matrix, given that $\mathbf{A} \geq 0$ and $\|\mathbf{A}\| < \mathbf{1}$, $(\mathbf{I} - \mathbf{A})$ is non-singular and the inverse of $(\mathbf{I} - \mathbf{A})$ exists. Taking the system one step further, the output is given by the following Leontief identity equation:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{y} = \mathbf{L}\mathbf{y}, \tag{3.6}$$

where $(\mathbf{I} - \mathbf{A})^{-\mathbf{1}} = \mathbf{L} = [l_{ij}]$ is a $n \times n$ Leontief inverse matrix, or the total requirements matrix. A detailed coverage of conditions necessary for existence of the Leontief inverse matrix $\mathbf{L}$ can be found in Waugh (1950).

The Leontief identity equation 3.6 is the key equation of the input-output framework, and the Leontief inverse, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-\mathbf{1}}$, is the central component in it. Given $\mathbf{L}$, the amount of total produced output $\mathbf{x}$ is determined solely by the structure of final demand $\mathbf{y}$. If the elements of the technical coefficients matrix a_{ij} represent direct requirements by an industry j for inputs from industry i, the Leontief inverse's elements l_{ij} describe total (direct and indirect) requirements. Thereby, the elements l_{ij} point at the fact that increases in final demand have larger impact on production of output in the economy than the initial direct effect that is reflected by the elements of the technical coefficients a_{ij}. A unique solution given by the Leontief identity equation 3.6 discloses how much output is generated directly and indirectly throughout the economy given a certain level of final demand. From analytical point of view, it is evident to see this larger 'round by round' production generation in an infinite sum series, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-\mathbf{1}} = \mathbf{I} + \mathbf{A} + \mathbf{A}^{\mathbf{2}} + \mathbf{A}^{\mathbf{3}} + \ldots$ In order to meet a certain level of final demand $\mathbf{y}$, sector j generates the initial amount of output $\mathbf{I}$ that is demanded plus directly the amount of output within itself and the rest of the economy as represented by the mix of inputs in the matrix $\mathbf{A}$. However, these direct requirements require production of their own inputs represented by $\mathbf{A}^{\mathbf{2}}$, $\mathbf{A}^{\mathbf{3}}$ and so on. These are the subsequent rounds of indirect effects. The results obtained through equation 3.6 represent certain average relationships characterized by technology in $\mathbf{A}$ and $\mathbf{L}$ that occurred in a particular accounting year at a given set of relative prices. The results of $\mathbf{L}$ are important for two reasons. Not all industries are directly related to each other, therefore, being able to quantify the indirect relationships allows to identify the interindustrial relationships correctly. Additionally, adding up the column elements of matrix $\mathbf{L}$ allows to quantitatively account for all direct and indirect effects on production within each sector j brought by a monetary unit change in final demand. The column total of the Leontief inverse for each sector j, $\sum_i l_{ij}$, is the total output multiplier for that sector, or a Type I output multiplier.

So far, what was discussed is called an open input-output demand-pull model. We kept household activities exogenous. Oosterhaven Piek and Stedler (1986) assert the

Type I multipliers probably underestimate the economic effects of an increase in final demand on output because an increased production requires more labor input which in turn raises household income which spurs additional demand for products and consequently production. Endogenizing households leads to the creation of the closed (with respect to households) demand-pull model, where the Leontief multipliers $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{\mathbf{-1}}$ are now called Type II output multipliers. The closed input-output model grants an insight into relationship between labor income and household consumption within the economy. Capturing such features as the employment income and its distribution to households, the closed input-output model can be seen as a simplified SAM. The model can be augmented further to include multiple households, thereby, allowing for a more detailed analysis of income distribution in the economy. For example, Miyazawa (1976) disaggregates the household sector into several groups based on pre-defined income brackets. Consumption coefficients by income group are then obtained and the effects of each income group on the economy via so-called Miyazawa input-output multipliers can be assessed. Other possible extensions to the closed input-output framework include various separation ideas of income payments and consumption of different household groups – varying demographic profiles, established residents vs migrants, employed vs unemployed, differing propensities to consume (Batey and Madden, 1999; Miller and Blair, 2009).

To construct the Type II system we move the column vector of household consumption $\mathbf{y_{hh}}$ within the matrix of final demand $\mathbf{y}$ and the row vector of workers' compensation $\mathbf{v_{hh}}'$ within the value added matrix $\mathbf{v}'$ inside the matrix of intermediate transactions $\mathbf{Z}$. Solving the household augmented Leontief demand-pull model generates the Type II Leontief inverse matrix $\mathbf{L}$ of dimension $(n+1) \times (n+1)$, where each element l_{ij} captures direct, indirect and induced effects in output generation caused by a stimulus to exogenous final demand. We follow Miller and Blair (2009) in formulation of the Type II system meaning we assume that the total household income consists of wages and that the total household consumption is funded by income generated in production. This is a significantly simplified view where ideally we at least should account for other types of household income and for exogenous household expenditure. For this reason, Oosterhaven Piek and Stedler (1986) state that the Type II multipliers probably overestimate the impact that households have on the economy due to the rigid assumptions between household income and consumption. If the Type I multipliers are said to capture direct and indirect effects that an additional final demand has on output generation throughout the economy, then the Type II multipliers also include the induced effects of household spending. These induced effects measure an additional impact of the demand for goods and services made by households on domestic production induced by the additional income received as a result of providing extra labor services to satisfy the exogenous final demand shock (Miller and Blair, 2009). The size of the induced effects - the difference between the Type I and Type II multipliers, also reflects the relative pay scales in sectors affected by the economic impact. Therefore, it should be expected that the induced effects will be higher when the direct and indirect effects of the impact involve expanding employment levels in high wage industries. From the applied perspective the reliability of the conclusions made on the basis of interpreting the Type II multipliers rests on the additional assumption with respect to household behavior that the average propensity to consume remains constant independent of the resulting impact in terms of increased income.

The type of multipliers discussed to this point concerned additional output generated throughout the economy in response to exogenous changes in final demand. However, policy analysts may be more interested in estimating the effects in terms of extra full-time employment or new value added created in the economy stimulated by this initial exogenous expenditure shock. To introduce additional income and employment forms of input-output multipliers, we first need to define $1 \times n$ vectors of coefficients for the n sectors of the economy. For example, in case of value added multipliers, the value added-output coefficients are derived by dividing total value added of sector j by total output of sector j, $\upsilon_j = v_j/x_j$. The 1xn vector of value added-output coefficients is then used to extend the demand-driven input-output framework in equation 3.6 to account for total value added generated in the economy, the $n \times 1$ vector **va** capturing the stimulated new income is given by:

$$\mathbf{va} = \mathbf{i}\upsilon(\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{y}, \tag{3.7}$$

where $\mathbf{i}$ is a $n \times 1$ vector of ones.

The $1 \times n$ vector $\upsilon(\mathbf{I} - \mathbf{A})^{-1}$ with elements $l_{\upsilon j}$ represents the value added generated across n sectors directly and indirectly to support an additional one monetary unit of final demand for sectoral output j. The elements of the vector of value added-output coefficients υ reflect the initial direct effect on value added generation in response to an additional unit of final demand for each sector j. The separate indirect effects can be obtained through subtracting the direct effects from the Type I value added multipliers which incorporate both direct and indirect effects.

Seeking sectoral $n \times n$ composition of these multipliers, an analyst needs to multiply the vector of the value added-output coefficients υ_j along the rows of the $n \times n$ Type I output multiplier matrix, $\mathbf{i}\upsilon(\mathbf{I} - \mathbf{A})^{-1}$. The $n \times n$ matrix of value added multipliers represents the amount of value added generated by industry j directly and indirectly through production linkages with other industries i in the supply chain to support one additional monetary unit of final demand for sectoral output j:

$$\mathbf{VA} = \begin{bmatrix} \upsilon_1 l_{11} & \upsilon_1 l_{12} & \cdots & \upsilon_1 l_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ \upsilon_i l_{i1} & \upsilon_i l_{i2} & \cdots & \upsilon_i l_{in} \\ \vdots & \vdots & \ddots & \vdots \\ \upsilon_n l_{n1} & \upsilon_n l_{n2} & \cdots & \upsilon_n l_{nn} \end{bmatrix}. \tag{3.8}$$

In order to calculate the Type II value added multipliers, the procedure is identical to the one described for the $(n+1) \times (n+1)$ Type II output multipliers with only difference of pre-multiplying the closed to households Leontief inverse matrix by the $1 \times (n+1)$ vector of value added-output coefficients υ. To separate the induced effects caused by the endogenized households, we need to subtract the Type I value added multipliers from the Type II value added multipliers. As before, the Type II value added multipliers represent the total effect (i.e. direct+indirect+induced) in terms of additional value added created in each sector j while satisfying the unit of additional demand for sector j's output.

The employment multipliers are calculated and interpreted in a similar analytical manner. The only adjustment in mathematical formulation is made in deriving the employment-output coefficients. For this derivation the full-time employment data is needed for each sector that is often published by the national statistical offices within an annual publication covering labor statistics. After that, the employment-output coefficients can be derived by dividing full time employment figure of sector j by total output of sector j, $emp_j = FTE_j/x_j$. Then the newly derived $1 \times n$ vector of coefficients replace the value added-output coefficients in equation 3.7 to provide the additional full time employment that is created throughout the economy in response to the shock in final demand for output of sector j. It is evident from analytical formulation of equation 3.7 that the higher the share of value added/employment per sector to total output, the larger the magnitude of the associated multiplier is expected to be.

3.5 Multiplier analysis

In this section we provide the framework for the analysis of different types of industry-specific input-output multipliers. The aim is to provide a comprehensive analysis of the evolution of production structure of the Russian economy which is founded on the observed interindustrial linkages during the period 1980-2006. Within the input-output framework the direct, indirect and induced effects of the existing production technology on aggregate and sectoral macro-economic indicators such as gross output, GDP, employment via exogenous final expenditure stimulus are estimated by the Type I and Type II (output, value added, employment) input-output multipliers. We also derive so-called net multipliers that, controlling for the size of an industry, assist in identifying the key or dominant sectors of an analyzed economy. Being able to track the inter-industry linkages and thereby separate different types of effects is the feature that makes the input-output framework so attractive to policy makers.

In our analysis we use the symmetric input-output tables derived by the IEF institute. In order to track the evolution of the production structure, we utilize the data in constant year 2000 prices. The IEF institute offers the input-output data in constant prices following the OKONh/OKP classification for years 1980-2006.

3.5.1 Net multipliers

Within the input-output framework there exist two different types of economic effects between a producing sector and the rest of the economy (Miller and Blair, 2009). The first type of inter-industry relationship occurs when spurred by a demand shock, output of a sector j subsequently requires more inputs to production that it demands from other sectors i. This kind of relationship is utilized within the demand-side input-output model when the interconnections of sector j with the 'upstream' or delivering inputs to production sectors i are termed backward linkages. However, in its turn the output of sector j can also be treated as an input to production in other sectors. In this case the causal relationship is characterized by forward linkages and the model is represented by the supply-side input-output model. The term forward linkage is utilized when formulating the interconnection of a particular sector j with those 'downstream' sectors to which it sells its output. The supply-side formulation has been extensively covered in the literature[6]. However, De Mesnard (2009a) shows that the simultaneous evaluation of the results obtained via a model that assumes the complementary inputs production function, as the Leontief demand-driven model, and the results obtained via a model where the production function follows the assumption of perfectly substitutable inputs, such as the Ghoshian supply-driven model, is conceptually not convincing[7]. De Mesnard (2009b) further shows that the mixing of the price and output effects within the supply-driven models provides results of the effects on quantities or prices, which are mixed and difficult to separate and interpret.

On the basis of the input-output model, Chenery and Watanabe (1958) were the first to provide quantitative evaluation of backward and forward linkages. The backward linkage constitutes the dependence on other industries and is formulated as a column sum of a matrix of technical coefficients $\mathbf{A}$. To capture total (direct and indirect) backward linkages in an economy, Rasmussen (1957) adviced using column sums of the total requirements matrix, $\mathbf{L} = [l_{ij}]$.

While measuring the backward linkages, it has become a common practice to multiply an output multiplier by industry's output to reflect the size. Interpreting the result

[6] Ghosh (1964); Dietzenbacher (1997); De Mesnard (2009a,b); Miller and Blair (2009).

[7] Due to its implausible and less informative nature, we will not cover the supply-driven Ghoshian model in this work.

as an estimate of the total impact of an industry using this practice leads to double counting. To address this problem, Oosterhaven and Stedler (2002) propose a concept of net backward multipliers. Miller and Blair (2009) point at the fact that $\mathbf{L\hat{y}}$ is a matrix whose ij's element describes output of sector i generated through the impulse of y_j. The row sum of $\mathbf{L\hat{y}}$ can be shown to be $\mathbf{L\hat{y}i} = \mathbf{Ly} = \mathbf{x}$ which transcribes to an output generated by each sector x_i while satisfying all final demands. The column sum of $\mathbf{L\hat{y}}$ can be written as $\mathbf{i'L\hat{y}}$ where the jth element of this row vector is the output that is required from all sectors to satisfy final demand from sector j, y_j. Therefore, the net backward output multipliers can be formulated as:

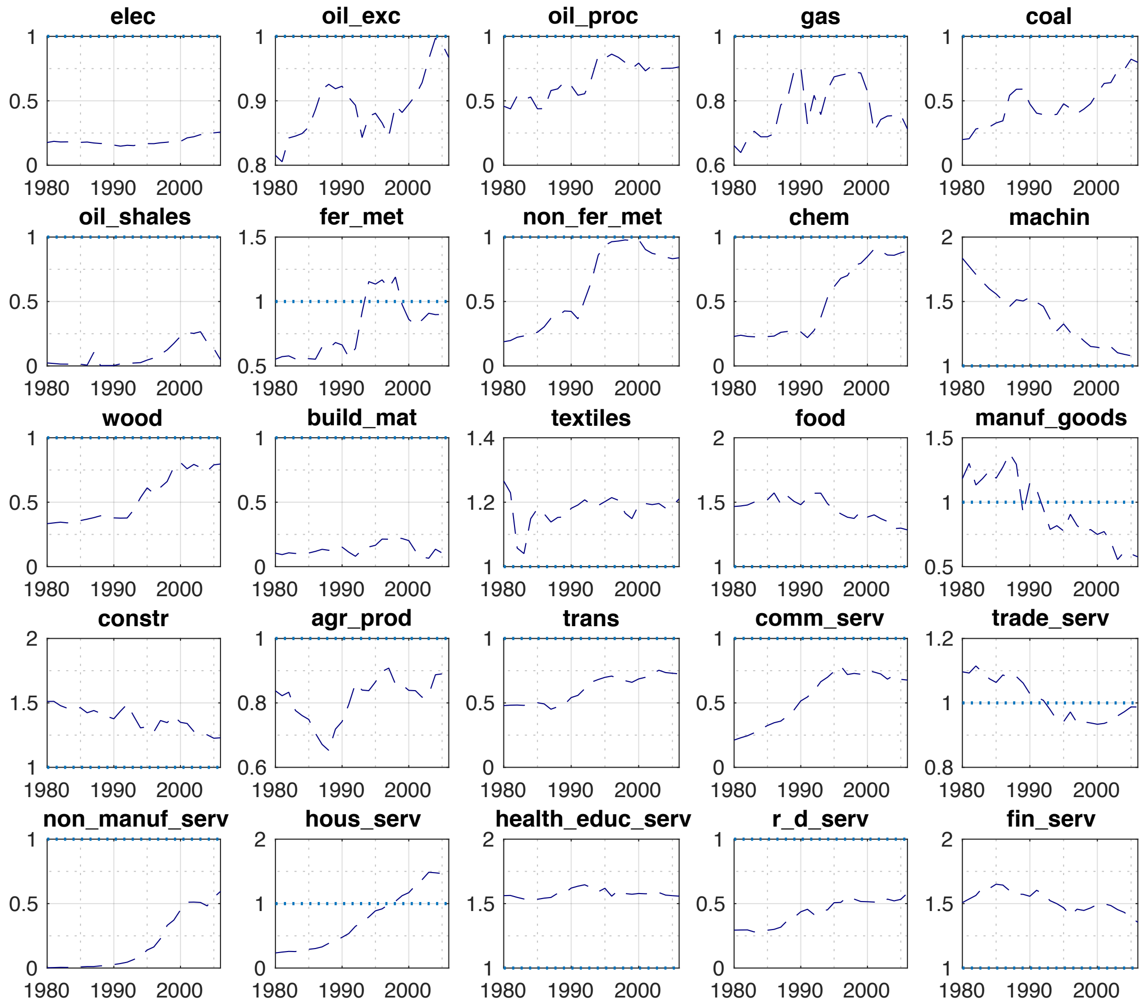
$$\mathbf{i'L\hat{y}\hat{x}^{-1}} = [\mathbf{i'L\hat{y}}][\mathbf{L\hat{y}i}]^{\mathbf{-1}} \tag{3.9}$$

The jth element of the row vector in equation 3.9 can be seen as a ratio:

$$(\mathbf{i'L\hat{y}\hat{x}^{-1}})_j = \frac{j\text{th column sum of } \mathbf{L\hat{y}}}{j\text{th row sum of } \mathbf{L\hat{y}}}. \tag{3.10}$$

The interpretation of equation 3.10 is the output generated in all industries by y_j divided by the output generated in sector j by all final demands. This is a kind of net backward linkage that helps determine net key sectors of the economy. In particular, if $(\mathbf{i'L\hat{y}\hat{x}^{-1}})_j > 1$ then economy-wide output generated by final demand in j is larger than the amount of j's output that is generated by all the other industries' final demands. Then sector j is said to be more important for the rest of the economy in terms of output generation than the other sectors are for sector j. We would normally expect industries that have high backwards linkages with other sectors of the economy to produce a net multiplier greater than one. And, vice versa, the industries with weak backward linkages to have a net multiplier that is less than one. For example, such sectors as construction, production of machinery, textiles, and food we would expect to have high level of interconnectedness with other sectors of the economy. Whereas, basic natural resources production would be expected to exhibit weaker links with other sectors. Equation 3.9 can be re-formulated for other types of multipliers, i.e. value added, employment, $\mathbf{\hat{m}}(= \mathbf{\hat{v}}, \mathbf{F\hat{T}E}) : \mathbf{m'\hat{x}^{-1}L\hat{y}\hat{m}^{-1}}$.

Figure 3.2 depicts the results for the net output multipliers derived for Russia using



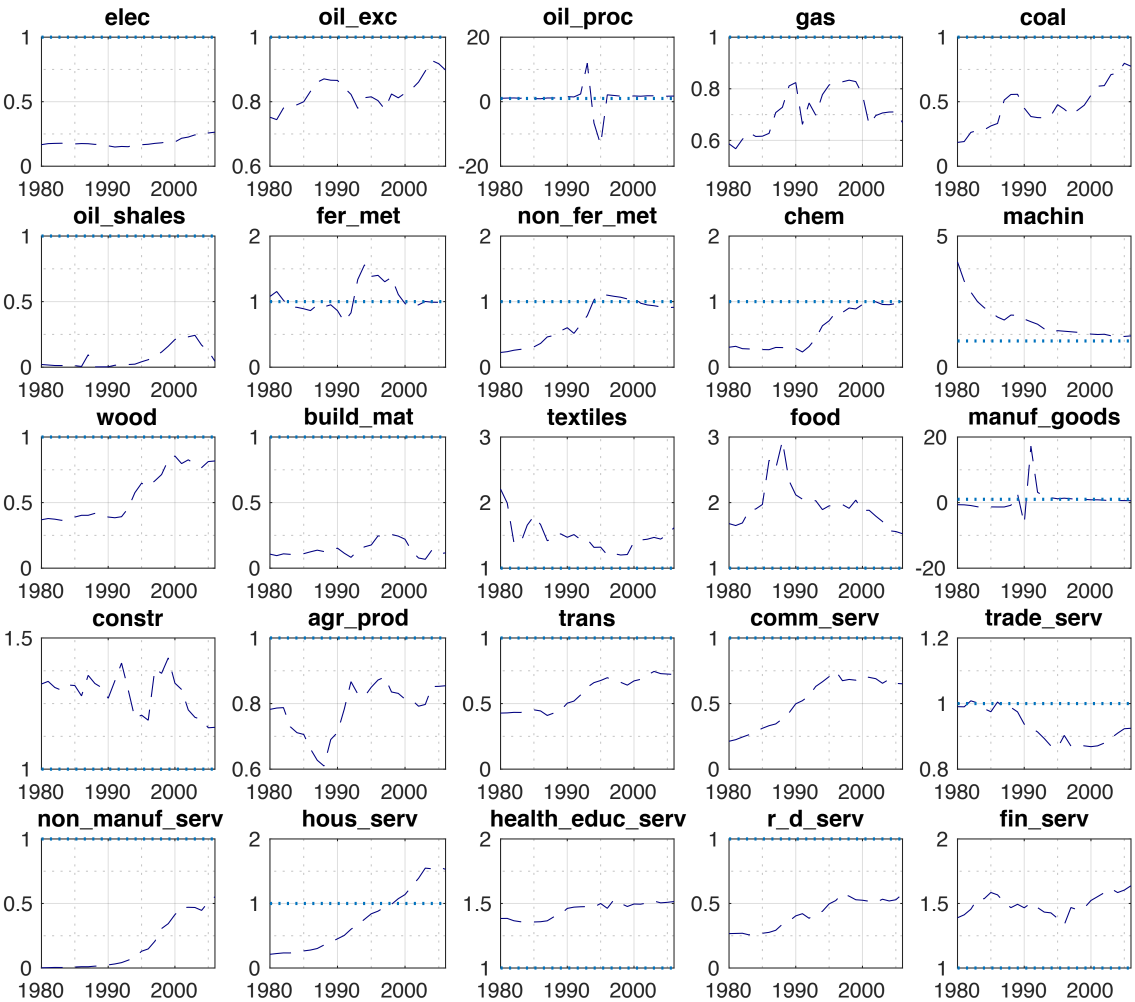
Note: Nomenclature in Appendix B, Table B.3

Figure 3.2: Net output multipliers

the data in constant prices (of year 2000) for 1980-2006. The economy is divided into 25 sectors, the sectoral abbreviation is described in Appendix B, Table B.3. A line at net output multiplier equals 1 represents a visual reference for the border of the sectoral dominance level.

As can be seen in Figure 3.2, in the beginning of the studied period 1980-2006 the 'Machinery' sector was of most importance in the Russian economy. Controlling for its size it exhibited the largest ability to stimulate additional production throughout the economy. Therefore, the demand for products of the 'Machinery' sector stimulates more output creation in all other sectors of the economy than other sectors in the 'Machinery' industry. From Table A.3 in Appendix A, we see that the 'Machinery' or 'Machine-building and metal working; medical equipment building' sector incorporates within itself production of all types of machinery and equipment in the economy. The importance of this sector for generation of output in the rest of the economy steadily declines throughout the studied period. The negative trend of manufacturing production, i.e. 'Machinery', 'Other manufactured goods', and growing importance of service sectors of the economy, i.e. 'Communal and (market) consumer services', 'Financial services', 'Trade', supports the view of gradual transition of the Russian economy from having an energy-intensive industrial specialization towards becoming a service-oriented market economy. The importance of service-providing sectors increases significantly over the years as can be seen in the bottom seven sub-figures of Figure 3.2, where most of them surpass the threshold of net multiplier equals 1, e.g. 'Trade', 'Communal and (market) consumer services', 'Health, education services', 'Financial services', and/or have positive trend, e.g. 'Communication services', 'Non-manufacturing services', 'R&D'. Despite of this, there can still be observed influence of such energy-intensive sectors as 'Construction', 'Food', 'Textile' and growing production trend of some sectors providing primary resources, i.e. 'Non-ferrous metals' that increased by 346% from 1980 to 2006, 'Coal' by 300%, 'Chemicals' by 290%, 'Oil extraction' by 108%. The full spectrum of the results is available in Appendix B, Table B.4.

The net value added multiplier results that show the ability of sectors to generate value added throughout the economy can be observed in Figure 3.3. For the most part the same industries that are leaders in stimulating output are also the most influential in value added creation throughout the economy. If the value of net value added multiplier is greater than 1, the final demand for industry j's output generates more value added in the rest of sectors i than the rest of sectors i in sector j. Therefore, we can observe that the 'Machinery', 'Food', 'Textiles', 'Construction' and financial, public and market services are among the most notable representatives. However, the importance of the aforementioned industrial sectors is declining while the service sectors exhibit growing importance in terms of their ability to stimulate value added. As before, starting 2000s the 'Chemicals', 'Non-ferrous metals', 'Coal' show the most rapid increase in their ability to create value in the rest of the economy. An interesting but short-lived behavior of the 'Oil processing' and 'Other manufacturing' sectors can be seen in the



Note: Nomenclature in Appendix B, Table B.3

Figure 3.3: Net value added multipliers

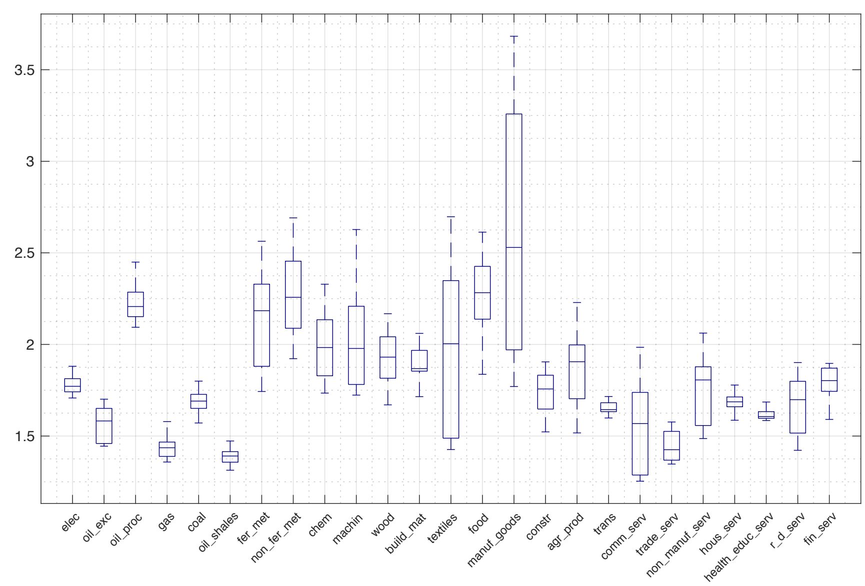
beginning-mid 1990s. It can be explained by the rapid restructuring that the Russian economy underwent after the dissolution of the Soviet Union. The full list of net value added multipliers is available in Appendix B, Table B.5.

3.5.2 Output multipliers

Type I output multipliers

The multiplier analysis is the foundation of the input-output framework that enables tracing direct and indirect impact linkages caused by the ripple effect between sectors via supply chain linkages in response to final demand for a particular commodity. The causal sequence of responses is triggered because any industry requires various inputs from other industries (domestic and foreign). It creates an add-on demand effect for the latter industry to already existing final demand. Analytically such ripple effect was represented in the previous section within the Leontief inverse matrix, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$. The value of the multiplier will depend on the strength of the backward linkages of the industries. Thus, according to the framework set up, any change within the system must be motivated by final demand.

The basis of the multiplier analysis are the output (production) multipliers. In the previous section we defined the output multipliers as the column sum of the Leontief inverse matrix $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$: $l_j = \sum_i l_{ij}$. For the simple (or Type I) output multipliers the output knock on effect in the economy is defined as the initial monetary worth of sector j's output generated to satisfy the additional final demand plus additional output created indirectly in all other sectors of the economy including sector j to serve as intermediate input deliveries.

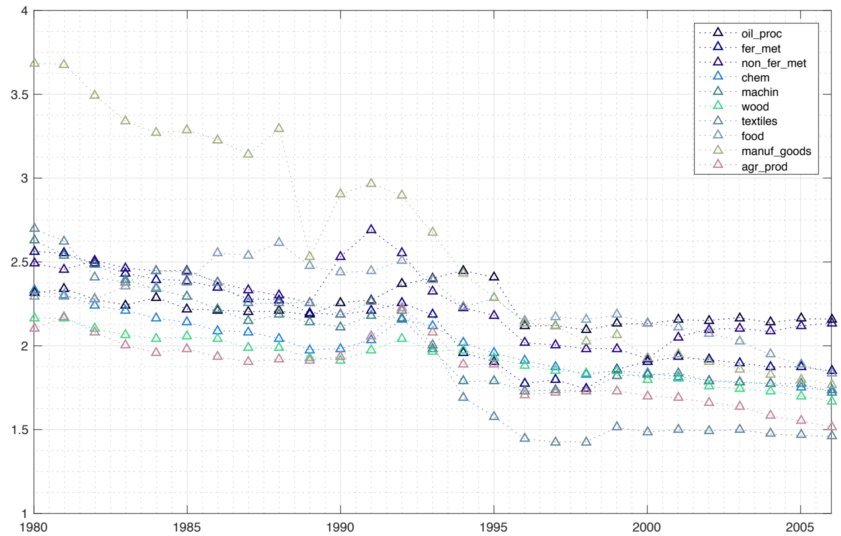


Note: Nomenclature in Appendix B, Table B.3

Figure 3.4: Type I output multipliers

Because of the multipliers' ability to analytically track domestic production inducements or the size of the production linkages with other sectors, they can be used as a 'go to' identifier of the economy's specialization. Figure 3.4 provides box plots of Type I output multipliers for the Russian economy for 1980-2006. Table 3.3 further denotes the top 10 sectoral output multipliers for each year of the studied period which enable us to better understand the specialization of the economy during that period. The full list of Type I output multipliers is available in Appendix B, Table B.6. The second column of Table 3.3 provides a record of the top (strongest backward linkages) Type I output multiplier for a given year, the third column provides a record of the second best Type I output multiplier for a given year, the fourth column of the third best, and so on. For example, in 1980 every additional (constant 2000) ruble worth of final demand for the products of 'Other manufactured products' stimulated production (directly and indirectly) throughout the entire economy worth of 3.7 rubles. It means that on average every ruble worth of final demand will result in 1 ruble of direct output production from the 'Manufactured goods' sector ($\mathbf{I}$ of $\mathbf{L} = \mathbf{I} + \mathbf{A} + \mathbf{A^2} + \mathbf{A^3} + \cdots$) and 2.7 rubles of additional output created in terms of intermediate input requirements from all of the sectors including itself ($\mathbf{L} - \mathbf{I} = \mathbf{A} + \mathbf{A^2} + \mathbf{A^2} + \cdots$). The 'Other manufacturing' industry under the OKONh classification includes sub-industries with industry codes starting with 19000 (Table B.2 in Appendix B). These are the 'Microbiological industry', 'Flour-and-cereals industry', 'Flour industry', 'Mixed fodder industry', 'Chemical and pharmaceutical industry', 'Medical equipment industry', 'Glass, porcelain and plastic medical items industry', 'Printing industry' and 'Industry, other'. By 2006 the importance of the 'Other manufacturing' sector decreased significantly where the stimulated economy-wide output fell to 1.8 constant 2000 rubles, which signifies a 52% decline, where the knock-on effects were responsible for only 0.8 rubles additionally generated in the economy.

Even though we cannot see the dynamics across years in Figure 3.4, it lets us understand the overall dispersion of the output multipliers in any given sector. For example, the 'Other manufacturing' sector has the largest absolute multiplier value but also the largest difference between the maximum and the minimum values. We cannot tell in what year the Type I output multiplier for the 'Other manufacturing' was at 3.7 and when it fell to 1.7 though we can see that the median across the time interval of 27 years is the highest among all sectors of the economy. Therefore, we can say that the 'Other manufacturing' is one of the influential sectors of the Russian economy in the period of 1980-2006. Similarly, we can see that such sectors as 'Oil processing', 'Ferrous metals', 'Non-ferrous metals', 'Machinery', 'Textiles', 'Food' are all at the top in terms of the size of backward linkages in output generation. Figure 3.4 suggests that the Russian economy is dominated by the energy-intensive industrial production.

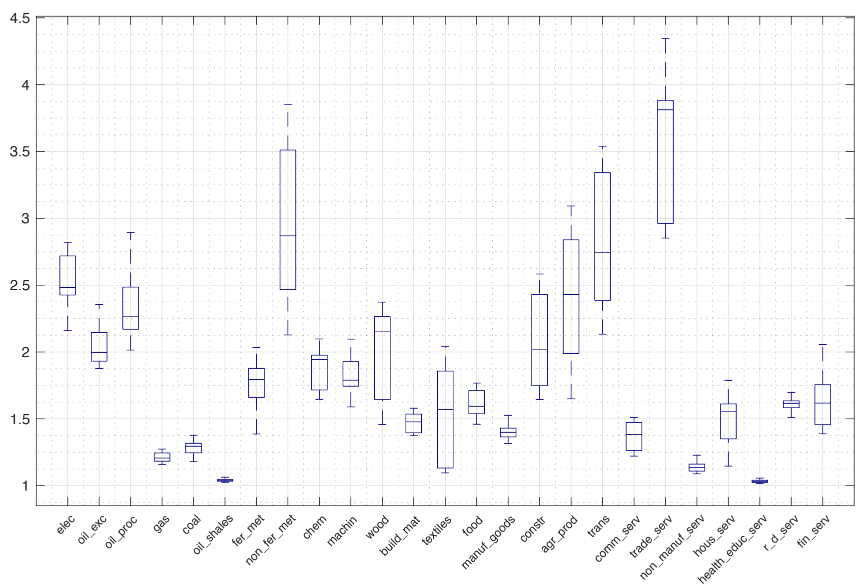


Note: Nomenclature in Appendix B, Table B.3

Figure 3.5: Top 10 Type I output multipliers

Figure 3.5 serves as a visual aid for the dynamics of the top 10 (by overall median) Type I output multipliers by economic activity. Even though Russian production remains energy-intensive, the trend for most of the industries is negative with a sharp fluctuation in the first half of the 1990s. The rapid change in the values of output multipliers during this period is indicative of the structural changes the economy was undergoing since the dissolution of the Soviet Union. This is the time when the institutional infrastructure (political and economic) underwent significant restructurization. During this period the private sector was established, the process of privatization of government property was initiated, and new productivity frontiers with the first structural adjustments were uncovered. The pricing politics was introduced and first major adjustments of relative prices, such as real wages, interest rates, and exchange rate, got concluded by the years 1995-1996. The evident leveling out of the multipliers after the years 1995-1996 could be pointing at the fact that the majority of catching up to becoming a market economy, or at least departing from being a centrally planned economy, was concluded by this time, and going forward the adjustments were less profound.

Overall, together with the results represented in Table 3.3, we can see that the production structure of the Russian economy (characterized by the strength of backward linkages) remains energy-intensive, however, there is a shift from specialization in manufacturing in the beginning of the studied period towards specialization in production of raw natural resources such as oil and (ferrous and non-ferrous) metals in the latter years. Along with strengthening of the production of primary materials, starting in the mid 1990s the service providing sectors gain more importance in terms of the relative magnitude of the backward linkages with other sectors. As can be seen in Table 3.3, starting in 1996 the 'R&D' sector appears in the top 10 Type I output multipliers, and starting 2002 the 'Financial services' and 'Communal and (market) consumer services' start to follow.



Note: Nomenclature in Appendix B, Table B.3

Figure 3.6: Type I input multipliers

It is possible to further analyze the Leontief inverse matrix derived in equation 3.6. So far we discussed the column summation of the Leontief inverse that yields the Type I output multipliers. If we, however, sum across the rows, $\sum_j l_{ij}$, we can identify the sectors that generate the largest amount of input requirements throughout the economy due to direct and indirect effects on production in response to final demand shocks to all industries in the economy. Figure 3.6 shows the input multipliers for the period 1980-2006. The top sectors responsible for the largest on average amount of input generation are 'Trade', 'Non-ferrous metals', 'Transportation', 'Agricultural production', 'Electricity', 'Oil extraction', 'Oil processing', 'Wood', 'Construction'. These sectors are strategically important in terms of industrial supply.

Year	Top multiplier by industry									
	1	2	3	4	5	6	7	8	9	10
1980	manuf_goods 3.6828	textiles 2.6972	machin 2.6274	fer_met 2.5633	non_fer_met 2.4911	chem 2.3288	oil_proc 2.3136	food 2.295	wood 2.1677	agr_prod 2.1021
1981	manuf_goods 3.6794	textiles 2.6238	fer_met 2.5501	machin 2.5418	non_fer_met 2.4567	oil_proc 2.3399	chem 2.3042	food 2.2941	agr_prod 2.1708	wood 2.1623
1982	manuf_goods 3.4949	non_fer_met 2.5084	fer_met 2.4905	machin 2.4846	textiles 2.4098	food 2.2782	oil_proc 2.2765	chem 2.2387	wood 2.0993	agr_prod 2.0787
1983	manuf_goods 3.3377	non_fer_met 2.4632	fer_met 2.4332	machin 2.3942	textiles 2.3781	food 2.3572	oil_proc 2.2434	chem 2.2089	wood 2.0652	build_mat 2.0038
1984	manuf_goods 3.2684	textiles 2.4477	non_fer_met 2.4467	fer_met 2.3964	food 2.3442	machin 2.3364	oil_proc 2.2886	chem 2.1643	wood 2.0434	build_mat 1.9862
1985	manuf_goods 3.2866	non_fer_met 2.4491	textiles 2.44	fer_met 2.3892	food 2.3811	machin 2.2928	oil_proc 2.2189	chem 2.14	wood 2.0542	build_mat 1.9915
1986	manuf_goods 3.2278	food 2.5513	textiles 2.3795	non_fer_met 2.3772	fer_met 2.3457	machin 2.2162	oil_proc 2.2126	chem 2.0903	wood 2.0399	build_mat 1.973
1987	manuf_goods 3.1414	food 2.5418	non_fer_met 2.3336	fer_met 2.2798	textiles 2.2526	oil_proc 2.2038	machin 2.148	chem 2.0832	wood 1.9892	build_mat 1.94
1988	manuf_goods 3.2941	food 2.6132	non_fer_met 2.2988	fer_met 2.2746	textiles 2.2556	oil_proc 2.2069	machin 2.1852	chem 2.0415	wood 1.9849	agr_prod 1.9189
1989	manuf_goods 2.5295	food 2.4765	textiles 2.2578	non_fer_met 2.2573	fer_met 2.1963	oil_proc 2.1844	machin 2.1378	chem 1.9758	wood 1.9308	agr_prod 1.9141
1990	manuf_goods 2.9032	non_fer_met 2.5322	food 2.4381	oil_proc 2.2581	fer_met 2.1852	textiles 2.1849	machin 2.1124	chem 1.9831	agr_prod 1.9346	non_manuf_serv 1.9176
1991	manuf_goods 2.9693	non_fer_met 2.691	food 2.4441	oil_proc 2.2723	textiles 2.2597	fer_met 2.213	machin 2.1805	agr_prod 2.0567	chem 2.0333	non_manuf_serv 1.983
1992	manuf_goods 2.8934	non_fer_met 2.5519	food 2.5104	oil_proc 2.3675	fer_met 2.2553	agr_prod 2.2289	textiles 2.2109	machin 2.1638	chem 2.1574	non_manuf_serv 2.0621
1993	manuf_goods 2.6734	oil_proc 2.4028	food 2.3905	non_fer_met 2.3275	fer_met 2.1842	chem 2.1194	agr_prod 2.0808	textiles 2.0038	machin 1.978	wood 1.9664
1994	oil_proc 2.4496	manuf_goods 2.4303	food 2.2315	non_fer_met 2.2284	chem 2.0188	wood 1.9768	fer_met 1.9586	agr_prod 1.8894	build_mat 1.8585	non_manuf_serv 1.8061
1995	oil_proc 2.4069	manuf_goods 2.2894	food 2.2825	non_fer_met 2.1812	chem 1.9567	wood 1.9261	fer_met 1.906	agr_prod 1.8888	build_mat 1.8695	non_manuf_serv 1.8229
1996	food 2.1454	manuf_goods 2.1371	oil_proc 2.1169	non_fer_met 2.018	chem 1.9111	wood 1.8841	build_mat 1.8679	r_d_serv 1.8672	fer_met 1.7743	machin 1.7281
1997	food 2.1742	oil_proc 2.1211	manuf_goods 2.1194	non_fer_met 2.0052	r_d_serv 1.9012	chem 1.8733	build_mat 1.8619	wood 1.8527	fer_met 1.7983	machin 1.7378
1998	food 2.1573	oil_proc 2.0937	manuf_goods 2.026	non_fer_met 1.9828	r_d_serv 1.8617	build_mat 1.8497	wood 1.839	chem 1.8268	fer_met 1.7432	machin 1.7286
1999	food 2.1842	oil_proc 2.1304	manuf_goods 2.0613	non_fer_met 1.9837	build_mat 1.8892	fer_met 1.8596	r_d_serv 1.8581	chem 1.8536	wood 1.8502	machin 1.8214
2000	food 2.1355	oil_proc 2.1318	manuf_goods 1.9284	non_fer_met 1.9222	fer_met 1.9059	build_mat 1.8567	chem 1.8346	r_d_serv 1.8317	machin 1.825	wood 1.8005
2001	oil_proc 2.1556	food 2.1136	non_fer_met 2.0533	manuf_goods 1.9518	fer_met 1.9321	build_mat 1.8536	machin 1.8385	chem 1.8167	wood 1.8075	r_d_serv 1.8039
2002	oil_proc 2.1505	non_fer_met 2.099	food 2.0731	fer_met 1.9173	manuf_goods 1.9022	build_mat 1.8198	fin_serv 1.7932	chem 1.7928	machin 1.7903	r_d_serv 1.7585
2003	oil_proc 2.1679	non_fer_met 2.1037	food 2.0301	fer_met 1.8979	manuf_goods 1.8626	fin_serv 1.8447	chem 1.7862	build_mat 1.7844	machin 1.7799	hous_serv 1.7784
2004	oil_proc 2.1377	non_fer_met 2.0848	food 1.9475	fer_met 1.8741	manuf_goods 1.8262	fin_serv 1.8235	machin 1.7769	chem 1.7713	hous_serv 1.7576	build_mat 1.7547
2005	oil_proc 2.1608	non_fer_met 2.1195	food 1.8858	fer_met 1.8746	fin_serv 1.8712	manuf_goods 1.799	hous_serv 1.795	machin 1.7757	chem 1.7504	elec 1.7423
2006	oil_proc 2.1595	non_fer_met 2.1355	fin_serv 1.8874	fer_met 1.8504	food 1.8367	hous_serv 1.8084	manuf_goods 1.7704	elec 1.7408	chem 1.7344	machin 1.7233

Table 3.3: Top 10 Type I output multipliers by economic activity for 1980-2006

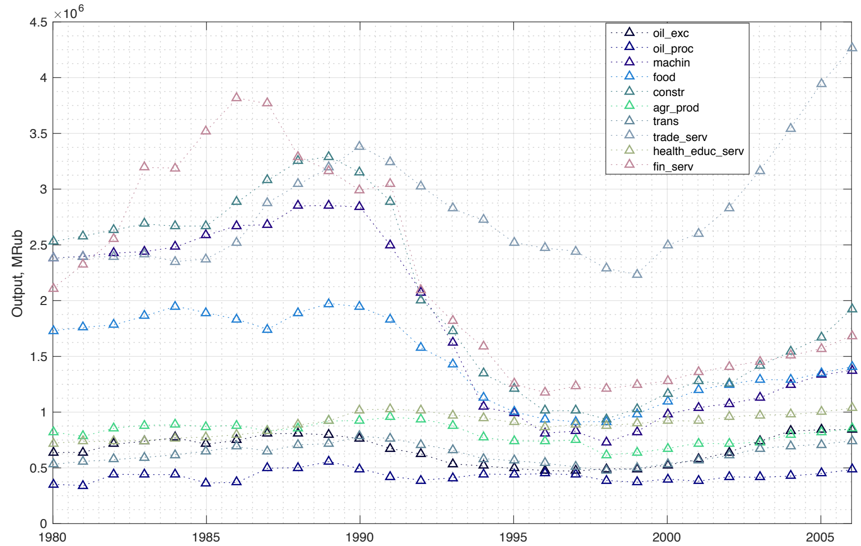
Accounting output multipliers

The Type I output multipliers that we discussed so far are interpreted either in terms of the size of the average inter-industrial linkages or in the context of measuring the effects of a marginal change in final demand on output. In contrast to the net multipliers the Type I multipliers do not account for the relative size of an industry nor for the amount of final demand which each sector drives through the economy via its multipliers. However, it is possible to perform a straight-forward manipulation to the Leontief equation (equation 3.6) which will account for both the relative size and the activity supported by an industry's final demand. This manipulation results in derivation of so-called accounting output multipliers. Mathematically, the accounting output multiplier is defined in the following way:

$$am_j = \sum_i l_{ij} y_j \tag{3.11}$$

From the mathematical formulation it follows that the larger the Type I output multiplier for sector j, $\sum_i l_{ij}$, and the larger the share of sectoral final demand, y_j, the greater the accounting multiplier, am_j, for this sector will be. The results obtained for the accounting multiplier measures for any given year provide a figure for each sector of the economy that estimates the contribution of this sector to the gross output generated as a result of the direct and indirect production processes which occur in order for this sector be able to satisfy its final demand. The full list of accounting measures calculated on the basis of equation 3.11 for years 1980-2006 is contained in Appendix B, Table B.7. The table of the accounting multiplier measures also includes a column that represents a ratio of sectoral output calculated while accounting for the size of sectoral backward linkages to economy's total output. This share is not the same as the share of the sectoral total output to economy's total output.

Figure 3.7 represents the top 10 sectors with highest accounting multiplier measures over the studied period. As can be seen, the 'Trade' sector became increasingly important over the years where it is able to stimulate the largest share of total output in the economy through direct and indirect channels with other industries while satisfying its final demand. In 1980 the 'Trade' sector contributed 2,380,734 million constant 2000 rubles (or 14.93%) worth to total output, whereas in 2006 the contribution to total



Note: Nomenclature in Appendix B, Table B.3

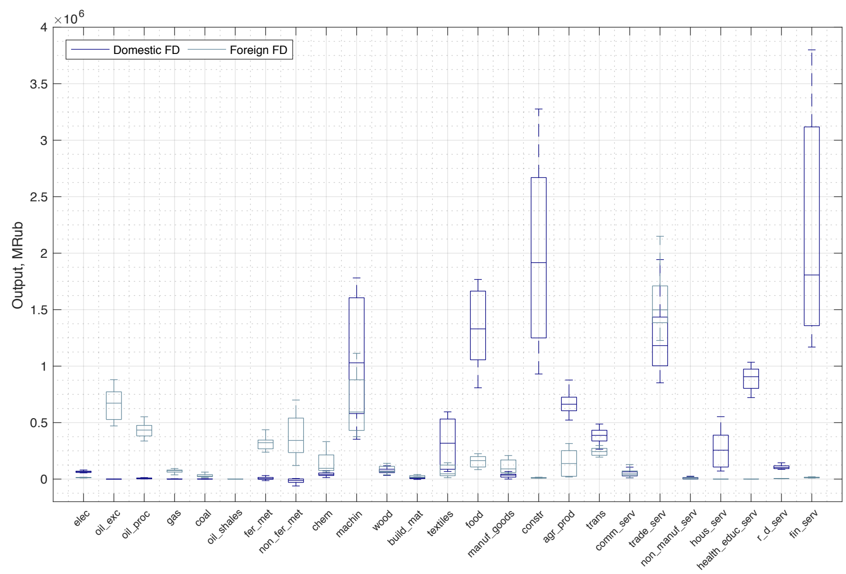
Figure 3.7: Top 10 accounting output multiplier measures

output increased to 4,265,282 million constant 2000 rubles (or 22.53%). Even though as we mentioned earlier the higher the value of the output multiplier and the higher the share of sectoral final demand to total, the greater the contribution to total output this sector will make. The situation with the 'Trade' industry is slightly different. Despite having one of the smallest Type I output multiplier values[8], it has the largest share of total final demand[9]. The size of the final demand for trade services drive the figure of accounting multiplier measure for this sector. Other notable contributors to gross output are depicted in Figure 3.7. On the contrary to the top 10 Type I output multipliers in Figure 3.5, where all top sectors were representative of the industrial production, when we account for the size of the final demand four out of the top 10 main contributors to the gross output are the service providing sectors - 'Transportation', 'Trade', 'Health, education, public services' and 'Financial services'. The sector with the highest Type I output multiplier (the 'Other manufacturing' production) has an elusively small contribution to the gross output, even in 1980 where the Type I output multiplier was at its peak of 3.7. Therefore, what might have seemed as an important industry in terms of the absolute size of Type I output multiplier has relatively small contribution in terms of total final demand.

[8]In 1980 it is 1.53 with ordinal rank 25/25 and in 2006 it is 1.37 with ordinal rank 24/25.

[9]In 1980 it is 1,553,986 million constant 2000 rubles or 19.3% of total final demand and in 2006 it is 3,120,942 million constant 2000 rubles or 27.86% of total final demand.

The sectors with top accounting output multiplier measures depicted in Figure 3.7 resemble those found to be key sectors in terms of the net multiplier values in Figure 3.2. For example, we determined that industries as 'Trade', 'Financial services', 'Health, education, public services', 'Food', Construction' and 'Machinery' are more important for the rest of the economy than the rest of the economy for these industries. The net multipliers measuring the two-way inter-industrial linkages (from industry j to the rest of the economy and from the rest of the economy to industry j) are normalized by the industry size e.g. sectoral output. Therefore, the net multiplier measure controls for the sectoral size while the accounting multiplier accounts for the share of the sectoral final demand to total final demand that way measuring the sectoral contribution to gross output through direct and indirect channels.



Note: Nomenclature in Appendix B, Table B.3

Figure 3.8: Accounting output multiplier measures by final demand type

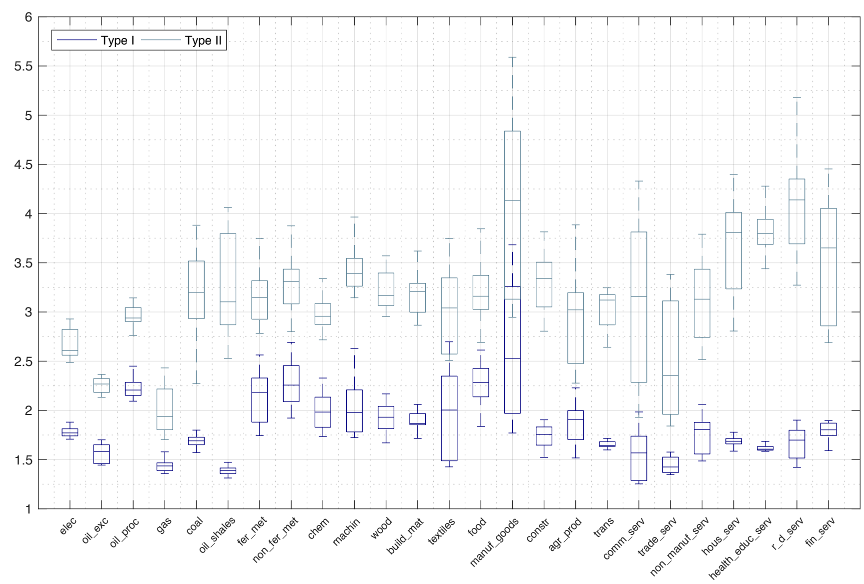
If we account for the domestic vs foreign final demand when calculating the accounting output multiplier measures, we get the results depicted in Figure 3.8. The top 10 sectors are identical to those obtained while utilizing the total final demand in estimation of the multiplier measure, as given by Figure 3.7. However, now we can see that the activity in such sectors as 'Financial services', 'Construction', 'Food', 'Health, education and public services', 'Agriculture', 'Transportation' is predominantly driven by domestic final demand. Whereas, the activity in such sectors as 'Oil excavation', 'Oil processing', 'Non-ferrous metals', 'Ferrous metals' is driven by foreign final demand. The important sectors in terms of net and accounting multipliers 'Trade' and 'Machinery' have shared domestic and foreign demand drivers. Across the entire time period of 27 years the share of domestic final demand to total final demand ranges between 70% during the Soviet period and 60% in post-Soviet years.

Type II output multipliers

The Type I output multipliers discussed in the previous sub-section kept the behavior of households exogenous to the production system. The household expenditure is the significant part of the aggregated final demand category $\mathbf{y}$ that drives production within the demand-driven input-output methodology. Miller and Blair (2009) state that, by not accounting for households' interactions with the production system of the economy, in an open demand-driven input-output model we fail to capture the induced effects that households might have on domestic output generation through the additional demand for domestically produced goods and services spurred by an extra income that they receive for provision of labor to satisfy the initial exogenous shock to final demand.

Within input-output methodology, the production system is called closed when the matrix of technical coefficients $\mathbf{A}$ is closed with respect to households. The closed demand-driven input-output model is derived from a symmetric input-output table and essentially involves endogenizing the behavior of households in the economic system (Miller and Blair, 2009). We previously explained that in order to endogenize households within the input-output framework we need to include the column vector $n \times 1$ of household consumption from the aggregate final demand and the row vector $1 \times n$ of workers' compensation from the aggregate value added as an additional row and column in the matrix of intermediate deliveries $\mathbf{Z}$ that now becomes of a dimension $(n+1) \times (n+1)$. Solving the augmented input-output model yields a Leontief inverse matrix also with a dimension $(n+1) \times (n+1)$ where each element now captures the direct, indirect and induced effects in output generation caused by a shock to exogenous final demand. The summation along each column yields $1 \times (n+1)$ row vector of the Type II output multipliers: $l_j^{II} = \sum_i l_{ij}^{II}$. The Type II multipliers capture direct, indirect and induced effects of exogenous change in final demand on production. To separate the induced effect from the total effect captured by the Type II multiplier is straightforward, we just need to subtract the Type I multiplier values from the Type II multiplier values, $\left[\sum_i l_{ij}^{II} - \sum_i l_{ij}^{I}\right]$.

Figure 3.9 illustrates the results for the Type II output multipliers derived using the Russian OKONh data in constant 2000 rubles for 1980-2006. To better see the induced effects by sector we also include the Type I output multipliers. A full record of direct, indirect and induced effects with respective ranking by economic activity for each year is available in Appendix B, Table B.6.

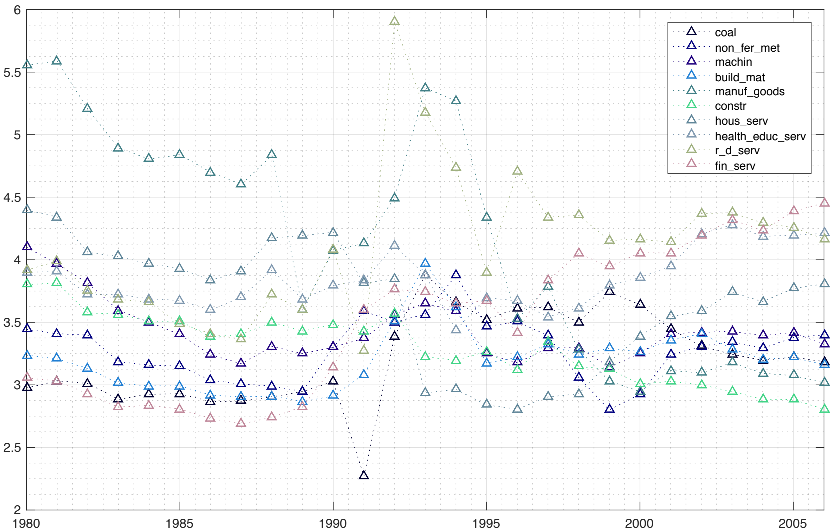


Note: Nomenclature in Appendix B, Table B.3

Figure 3.9: Type I and Type II output multipliers

The top 10 sectors with the highest median Type II output multiplier values across 27 years are depicted in Figure 3.10. Table 3.4 provides the top 10 Type II output multiplier values for each year of the studied period.

In Figure 3.9 we see that generally all sectors of the economy receive significant induced boost through extra rounds of domestic production triggered by extra demand for domestic goods and services by households in response to additional income received for their labor as a consequence of the initial exogenous final demand shock. For example, the leader in Type I output multipliers category the 'Other manufacturing' production sector (abbreviated as 'manuf_goods') in 1980 had Type II output multiplier of 5.55 (also ranks #1/25), where, as can be seen in Appendix B, Table B.6, the direct

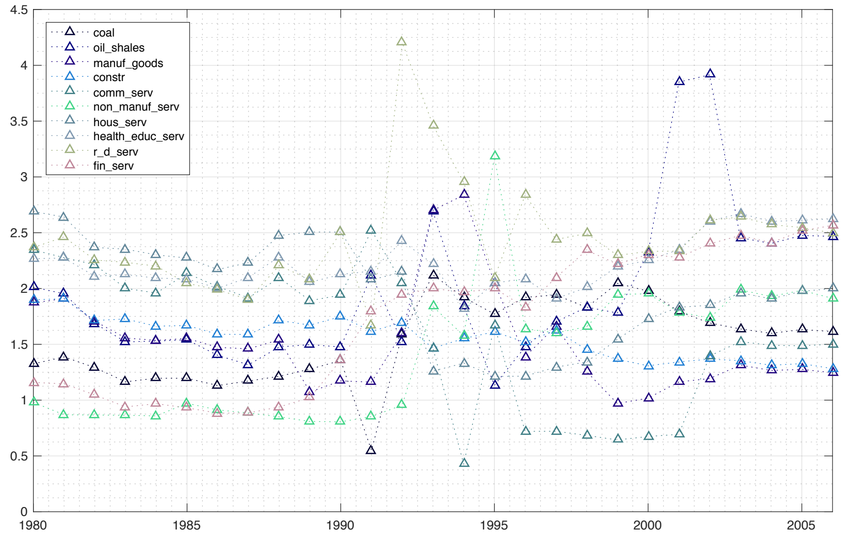


Note: Nomenclature in Appendix B, Table B.3

Figure 3.10: Top 10 Type II output multipliers

and indirect effects account for 3.68 (rank #1/25) and induced effect for 1.87 (rank #7/25). Overall, it means that every ruble of extra exogenous injection for products of this sector on average is expected to generate output throughout the entire economy estimating 5.55 rubles. Most of this stimulated production (worth of 3.68 rubles) is driven by the strong supply chain linkages, however still a significant portion (1.87 rubles) is triggered by the extra expenditure of households. In 2006 the 'Other manufacturing' sector has Type II output multiplier of 3.02 (now rank #12/25), of which the direct and indirect effects account for 1.77 (rank #7) and the induced effects account for 1.25 (rank #15). If we look at Figure 3.10, we notice that four out of top 10 sectors are service-oriented sectors. Combined with Table 3.4, the observed general tendency along the studied period is such that industrial sectors, such as manufacturing and machinery production, lose their leading positions to service-oriented sectors, such as R&D and financial services. The shift in specialization from manufacturing to services is especially noticeable after the first half of the 1990s when the rapid restructuring of the economy took place. This is in agreement with our previous conclusions when we discussed net and Type I multipliers.

In general, the extent with which the households can add to the production throughout the economy given the extra final demand for a sector's product depends on the



Note: Nomenclature in Appendix B, Table B.3

Figure 3.11: Sectors with top 10 induced effects

labor intensity of this sector[10]. The higher the sectoral labor intensity, the greater the effect induced by households on output generation is expected to be. The individual labor intensities by sector are presented in Appendix B, Table B.8. For example, the 'Communal and (market) consumer services' sector (abbreviated as 'hous_serv') in 1980 had the Type I output multiplier of 1.71 (rank #17/25) but the induced effect of this sector is 2.69 (rank #1/25) which elevated its position #2 of 25 among the Type II multipliers, right after the 'Other manufacturing' sector. In Appendix B, Table B.8 we can see that the labor intensity of this sector in 1980 was 70%. The underlying reason for a low Type I multiplier was buried in the fact that the main input requirement to production for this sector is labor that was unaccounted for when households were held exogenous to production system. When this is addressed, we see that the importance of the 'Communal and (market) consumer services' sector becomes significantly higher. Over the studied period the importance of the 'Communal and (market) consumer services' sector became even more apparent when the economy made a gradual shift towards becoming a service-oriented market economy after the dissolution of the Soviet Union. Other important sectors when accounting for sectoral labor intensity are service sectors such as the 'Public health, sports, social security, education and

[10]The labor intensity is defined as a share of sectoral labor input in terms of wages and salaries to sectoral total input requirements.

culture', 'R&D' 'Financial services', 'Post and communication services', 'Transportation' as well as the 'Construction' sector and some primary energy sectors such as the 'Coal' and 'Other fuel' sectors. The sectors with the highest median induced effects are illustrated in Figure 3.11. Strong backward production linkages and high sectoral labor intensity guarantees a high Type II output multiplier value. If we observe weakening of the sectoral interconnectedness or the falling share of sectoral labour input to total input requirements, we will see a decline in relative importance of the sector. We can observe this tendency in such industrial and primary resources sectors as 'Oil processing', 'Electricity', 'Ferrous metals', 'Non-ferrous metals', 'Chemical', 'Food', 'Other manufacturing'.

Year	Top multiplier by industry 1	2	3	4	5	6	7	8	9	10
1980	5.55	4.40	4.33	4.10	3.92	3.90	3.80	3.75	3.75	3.61
	manuf_goods	hous_serv	comm_serv	machin	r_d_serv	health_educ_serv	constr	textiles	fer_met	agr_prod
1981	5.59	4.34	4.19	3.99	3.97	3.90	3.81	3.74	3.73	3.65
	manuf_goods	hous_serv	comm_serv	r_d_serv	machin	health_educ_serv	constr	fer_met	agr_prod	textiles
1982	5.20	4.16	4.06	3.81	3.75	3.72	3.59	3.58	3.47	3.40
	manuf_goods	comm_serv	hous_serv	machin	r_d_serv	health_educ_serv	fer_met	constr	agr_prod	non_fer_met
1983	4.89	4.03	3.86	3.72	3.68	3.60	3.56	3.40	3.29	3.28
	manuf_goods	hous_serv	comm_serv	health_educ_serv	r_d_serv	machin	constr	fer_met	trade_serv	textiles
1984	4.80	3.97	3.77	3.69	3.66	3.51	3.50	3.37	3.35	3.29
	manuf_goods	hous_serv	comm_serv	health_educ_serv	r_d_serv	constr	machin	textiles	fer_met	trade_serv
1985	4.84	3.93	3.90	3.67	3.51	3.49	3.40	3.36	3.33	3.25
	manuf_goods	hous_serv	comm_serv	health_educ_serv	constr	r_d_serv	machin	textiles	fer_met	trade_serv
1986	4.70	3.84	3.74	3.60	3.45	3.41	3.38	3.24	3.24	3.23
	manuf_goods	hous_serv	comm_serv	health_educ_serv	food	r_d_serv	constr	machin	trade_serv	textiles
1987	4.60	3.91	3.70	3.66	3.46	3.40	3.36	3.17	3.15	3.12
	manuf_goods	hous_serv	health_educ_serv	comm_serv	food	constr	r_d_serv	machin	fer_met	agr_prod
1988	4.84	4.18	3.92	3.83	3.72	3.55	3.50	3.31	3.18	3.13
	manuf_goods	hous_serv	health_educ_serv	comm_serv	r_d_serv	food	constr	machin	fer_met	wood
1989	4.19	3.69	3.60	3.60	3.59	3.43	3.33	3.25	3.10	3.10
	hous_serv	health_educ_serv	manuf_goods	r_d_serv	comm_serv	constr	food	machin	textiles	fer_met
1990	4.22	4.09	4.08	3.79	3.63	3.48	3.30	3.30	3.27	3.14
	hous_serv	r_d_serv	manuf_goods	health_educ_serv	comm_serv	constr	machin	non_fer_met	food	fer_met
1991	4.19	4.13	3.84	3.81	3.60	3.59	3.43	3.43	3.37	3.27
	comm_serv	manuf_goods	health_educ_serv	hous_serv	fin_serv	non_fer_met	oil_shales	constr	machin	r_d_serv
1992	5.90	4.50	4.11	3.89	3.85	3.78	3.76	3.66	3.57	3.56
	r_d_serv	manuf_goods	health_educ_serv	agr_prod	hous_serv	food	fin_serv	comm_serv	constr	machin
1993	5.37	5.18	4.06	3.98	3.97	3.88	3.88	3.85	3.79	3.76
	manuf_goods	r_d_serv	oil_shales	wood	build_mat	coal	health_educ_serv	food	non_manuf_serv	agr_prod
1994	5.27	4.73	4.20	4.11	3.88	3.66	3.66	3.65	3.62	3.59
	manuf_goods	r_d_serv	wood	oil_proc	non_fer_met	coal	textiles	fin_serv	build_mat	machin
1995	5.00	4.34	3.90	3.70	3.67	3.52	3.47	3.41	3.39	3.31
	non_manuf_serv	manuf_goods	r_d_serv	health_educ_serv	fin_serv	coal	non_fer_met	wood	food	oil_proc
1996	4.70	3.67	3.61	3.55	3.53	3.51	3.42	3.24	3.22	3.18
	r_d_serv	health_educ_serv	coal	wood	manuf_goods	non_fer_met	fin_serv	food	build_mat	machin
1997	4.34	3.83	3.78	3.62	3.56	3.54	3.39	3.34	3.33	3.32
	r_d_serv	fin_serv	manuf_goods	coal	wood	health_educ_serv	non_fer_met	constr	build_mat	food
1998	4.36	4.05	3.62	3.50	3.36	3.30	3.28	3.27	3.25	3.15
	r_d_serv	fin_serv	health_educ_serv	coal	wood	machin	manuf_goods	non_manuf_serv	build_mat	food
1999	4.15	3.94	3.80	3.74	3.58	3.29	3.18	3.17	3.14	3.13
	r_d_serv	fin_serv	health_educ_serv	coal	non_manuf_serv	build_mat	hous_serv	oil_shales	machin	trans
2000	4.16	4.06	3.86	3.69	3.64	3.52	3.39	3.27	3.25	3.25
	r_d_serv	fin_serv	health_educ_serv	oil_shales	coal	non_manuf_serv	hous_serv	build_mat	machin	trans
2001	5.26	4.14	4.05	3.95	3.55	3.45	3.41	3.35	3.35	3.24
	oil_shales	r_d_serv	fin_serv	health_educ_serv	hous_serv	coal	machin	build_mat	non_manuf_serv	non_fer_met
2002	5.32	4.37	4.21	4.19	3.59	3.42	3.41	3.31	3.31	3.27
	oil_shales	r_d_serv	health_educ_serv	fin_serv	hous_serv	machin	build_mat	coal	non_fer_met	non_manuf_serv
2003	4.38	4.32	4.28	3.89	3.74	3.53	3.43	3.35	3.29	3.24
	r_d_serv	fin_serv	health_educ_serv	oil_shales	hous_serv	non_manuf_serv	machin	non_fer_met	build_mat	coal
2004	4.29	4.23	4.19	3.83	3.67	3.45	3.39	3.29	3.21	3.20
	r_d_serv	fin_serv	health_educ_serv	oil_shales	hous_serv	non_manuf_serv	machin	non_fer_met	build_mat	coal
2005	4.39	4.26	4.20	3.93	3.77	3.53	3.42	3.38	3.22	3.22
	fin_serv	r_d_serv	health_educ_serv	oil_shales	hous_serv	non_manuf_serv	machin	non_fer_met	coal	build_mat
2006	4.45	4.21	4.17	3.94	3.81	3.40	3.40	3.32	3.19	3.18
	fin_serv	health_educ_serv	r_d_serv	oil_shales	hous_serv	non_fer_met	non_manuf_serv	machin	coal	trans

Table 3.4: Top 10 Type II output multipliers by economic activity for 1980-2006

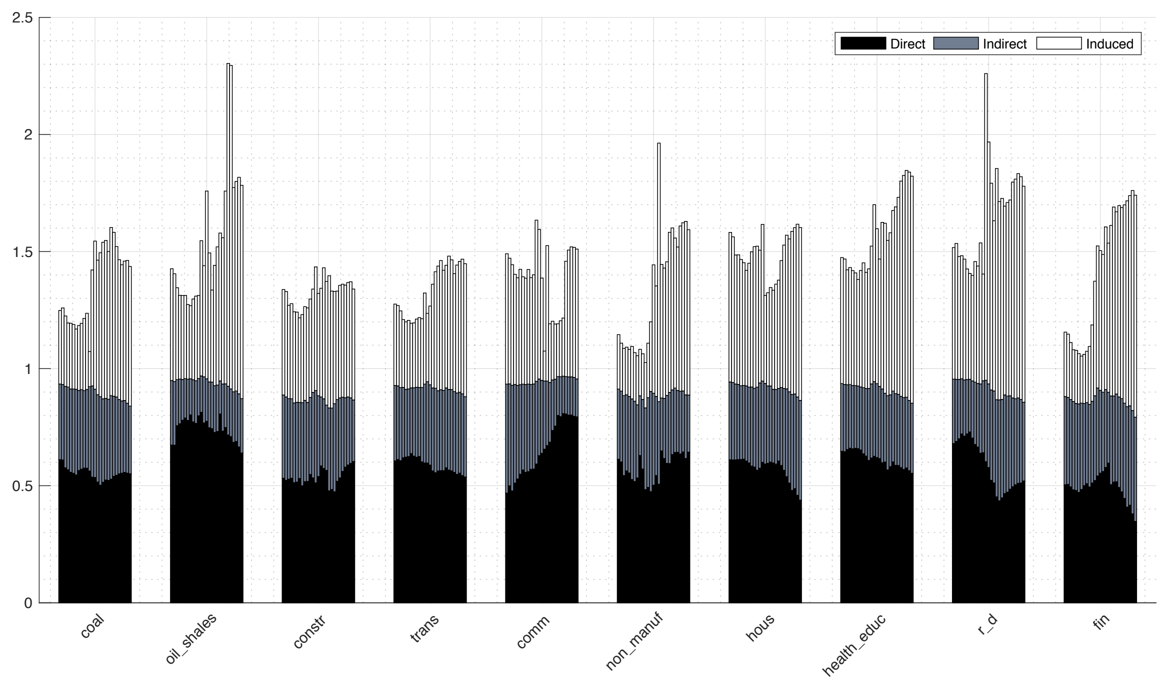
3.5.3 GDP multipliers

The output multipliers discussed in the previous section indicate where increases in final demand would have the greatest impact in terms of output worth generated throughout the economy. However, a policy maker might be more interested in estimating the effects of additional spending on the amount of value added or employment that can be created in the economy rather than just gross output. This objective can be achieved via calculation of value added-output and employment-output input-output multipliers. This section is dedicated to discussion of value added (GDP) input-output multipliers derived for the Russian economy on the basis of input-output data in constant 2000 prices for the period of 1980-2006.

In this section we derive Type II value added multiplier measures on the basis of which we can obtain total (direct, indirect and induced) effects of an exogenous increase in final demand through enhanced production on sectoral value added level. As before, the direct and indirect effects are obtained via Type I multiplier and the induced effects can be calculated by extending the basic Leontief system to incorporate households. Therefore, we answer the question how much value added is generated in all sectors of the economy when we increase the demand for products and services of sector j by 1 ruble.

The first step in calculating the GDP multipliers is to obtain the value added-output coefficients, which later are multiplied by the Leontief inverse to estimate the desired effect. From analytical point of view it is easy to see that the lower the value of the value added-output coefficient for a given sector j and the lower the value of a Leontief multiplier, the lower the magnitude of the GDP-output multiplier is expected to be. Normally, the supply side of the input-output table in basic prices consists of the intermediate transactions, value added, imports and taxes on products. Therefore, the higher the imports share use to total input requirements by sector, the smaller the resulting value added multiplier for this sector will be.

The full list of results by effect class and associative ranking is available in Appendix B, Table B.9. The top 10 Type II value added-output multiplier values are presented in Table 3.5. And, the sectors with the highest median Type II value added-output multipliers by effect type over 1980-2006 are depicted in Figure 3.12. Figure 3.12 allows to track evolution of different type of effects throughout the studied period.



Note: Nomenclature in Appendix B, Table B.3

Figure 3.12: Top 10 Type II GDP-output multipliers by effect

As can be seen in Table 3.5, in 1980 the sector with the highest Type II value added multiplier was the ’Communal and (market) consumer services’ sector with multiplier value of 1.58. It means that for every ruble spent on services of this sector, it would trigger through enhanced production rounds value added estimating 1.58 rubles. With the aid of Appendix B, Table B.9 we can see that 0.61 or 39% is generated directly in the ’Communal and (market) consumer services’ sector, whereas, 0.33 or 21% is generated in other sectors of the economy through the backward linkages of this sector with other sectors of the economy providing its input requirements. An additional 0.64 or 41% is generated across the entire economy in response to induced production and spending by households to satisfy the additional rounds of increased domestic consumption.

As can be seen in Figure 3.12 the majority of sectors with highest levels of value added multipliers are service providing sectors such as ’Financial services’, ’R&D’, ’Communal and (market) consumer services’, ’Health and education services’, ’Communication services’. These sectors are accompanied by the ’Coal’, ’Other fuel’ and ’Construction’ industries. Importance of these industries remains relatively stable across the studied period of 1980-2006 where the majority of sectors stay within the top 10 industries. The relative ranking among direct, indirect, and induced effects types also remains relatively stable across the studied period, where the strongest direct and induced value added effects are observed in service providing sectors and the strongest indirect effects are seen in the industrial production sectors.

	Top multiplier by industry									
Year	1	2	3	4	5	6	7	8	9	10
1980	1.58	1.52	1.49	1.47	1.43	1.34	1.33	1.28	1.25	1.23
	hous_serv	r_d_serv	comm_serv	health_educ_serv	oil_shales	constr	trade_serv	trans	coal	agr_prod
1981	1.56	1.53	1.47	1.47	1.41	1.33	1.33	1.27	1.26	1.23
	hous_serv	r_d_serv	comm_serv	health_educ_serv	oil_shales	constr	trade_serv	trans	coal	agr_prod
1982	1.49	1.48	1.44	1.42	1.36	1.35	1.27	1.25	1.22	1.18
	hous_serv	r_d_serv	comm_serv	health_educ_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1983	1.49	1.48	1.43	1.4	1.35	1.31	1.28	1.21	1.19	1.15
	hous_serv	r_d_serv	health_educ_serv	comm_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1984	1.47	1.47	1.42	1.39	1.35	1.31	1.24	1.2	1.19	1.14
	r_d_serv	hous_serv	health_educ_serv	comm_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1985	1.45	1.43	1.42	1.41	1.34	1.31	1.24	1.21	1.19	1.13
	hous_serv	r_d_serv	comm_serv	health_educ_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1986	1.42	1.41	1.39	1.38	1.32	1.27	1.22	1.19	1.17	1.12
	hous_serv	r_d_serv	comm_serv	health_educ_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1987	1.45	1.42	1.4	1.39	1.31	1.27	1.23	1.2	1.18	1.14
	hous_serv	health_educ_serv	r_d_serv	comm_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1988	1.5	1.46	1.45	1.42	1.31	1.3	1.26	1.21	1.19	1.12
	hous_serv	r_d_serv	health_educ_serv	comm_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1989	1.52	1.44	1.41	1.39	1.33	1.31	1.26	1.22	1.21	1.12
	hous_serv	r_d_serv	health_educ_serv	comm_serv	trade_serv	oil_shales	constr	trans	coal	agr_prod
1990	1.54	1.52	1.43	1.4	1.34	1.31	1.3	1.24	1.21	1.19
	r_d_serv	hous_serv	health_educ_serv	comm_serv	trade_serv	oil_shales	constr	coal	trans	fin_serv
1991	1.63	1.55	1.52	1.51	1.4	1.37	1.34	1.32	1.22	1.21
	comm_serv	oil_shales	health_educ_serv	hous_serv	r_d_serv	fin_serv	constr	trans	build_mat	trade_serv
1992	2.26	1.7	1.62	1.59	1.52	1.44	1.43	1.42	1.41	1.4
	r_d_serv	health_educ_serv	hous_serv	comm_serv	fin_serv	oil_shales	constr	coal	agr_prod	build_mat
1993	1.97	1.76	1.61	1.6	1.54	1.52	1.5	1.5	1.44	1.4
	r_d_serv	oil_shales	manuf_goods	health_educ_serv	coal	build_mat	fin_serv	wood	non_manuf_serv	agr_prod
1994	1.79	1.64	1.55	1.49	1.49	1.47	1.46	1.39	1.36	1.36
	r_d_serv	manuf_goods	wood	oil_shales	fin_serv	health_educ_serv	coal	build_mat	oil_proc	trans
1995	1.96	1.63	1.62	1.61	1.53	1.5	1.49	1.43	1.41	1.39
	non_manuf_serv	r_d_serv	health_educ_serv	fin_serv	comm_serv	manuf_goods	coal	constr	trans	wood
1996	1.85	1.62	1.54	1.54	1.45	1.44	1.44	1.42	1.37	1.33
	r_d_serv	health_educ_serv	coal	fin_serv	non_manuf_serv	oil_shales	trans	wood	constr	hous_serv
1997	1.71	1.61	1.55	1.55	1.52	1.46	1.43	1.43	1.4	1.36
	r_d_serv	fin_serv	health_educ_serv	coal	oil_shales	trans	wood	non_manuf_serv	constr	hous_serv
1998	1.73	1.69	1.58	1.58	1.5	1.46	1.42	1.38	1.37	1.33
	r_d_serv	fin_serv	health_educ_serv	oil_shales	coal	non_manuf_serv	trans	hous_serv	wood	constr
1999	1.69	1.68	1.67	1.6	1.58	1.56	1.46	1.44	1.35	1.33
	r_d_serv	health_educ_serv	fin_serv	coal	non_manuf_serv	oil_shales	hous_serv	trans	build_mat	constr
2000	1.76	1.71	1.7	1.69	1.6	1.58	1.53	1.48	1.36	1.33
	oil_shales	r_d_serv	fin_serv	health_educ_serv	non_manuf_serv	coal	hous_serv	trans	build_mat	constr
2001	2.3	1.73	1.72	1.69	1.57	1.56	1.52	1.46	1.41	1.36
	oil_shales	health_educ_serv	r_d_serv	fin_serv	hous_serv	non_manuf_serv	coal	trans	build_mat	constr
2002	2.3	1.8	1.8	1.7	1.55	1.52	1.47	1.46	1.44	1.41
	oil_shales	health_educ_serv	r_d_serv	fin_serv	hous_serv	non_manuf_serv	coal	comm_serv	build_mat	trans
2003	1.83	1.81	1.77	1.72	1.61	1.59	1.51	1.44	1.44	1.4
	health_educ_serv	r_d_serv	oil_shales	fin_serv	non_manuf_serv	hous_serv	comm_serv	coal	trans	build_mat
2004	1.85	1.83	1.8	1.74	1.62	1.6	1.52	1.46	1.46	1.41
	health_educ_serv	r_d_serv	oil_shales	fin_serv	non_manuf_serv	hous_serv	comm_serv	coal	trans	build_mat
2005	1.84	1.82	1.82	1.76	1.63	1.62	1.52	1.47	1.46	1.42
	health_educ_serv	r_d_serv	oil_shales	fin_serv	non_manuf_serv	hous_serv	comm_serv	trans	coal	build_mat
2006	1.82	1.78	1.78	1.74	1.6	1.59	1.51	1.45	1.44	1.39
	health_educ_serv	oil_shales	r_d_serv	fin_serv	hous_serv	non_manuf_serv	comm_serv	trans	coal	build_mat

Table 3.5: Top 10 Type II GDP-output multipliers for 1980-2006

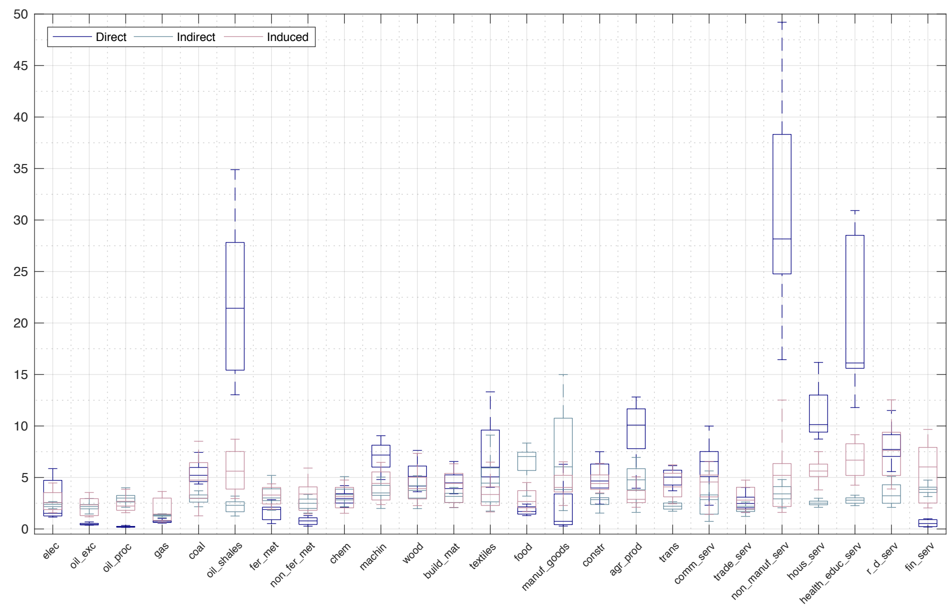
3.5.4 Employment multipliers

Another kind of multiplier popular among policy making practices is the employment-output multiplier. This multiplier is utilized when a policy maker is interested in an estimation of the causal effect of extra expenditure within a specific industry on the creation of physical employment in the economy. Here again we assume no supply constraints and that there are fixed coefficients in production and consumption functions. It means that all responses to changes in demand occur through changes in output where there is no adjustment in prices and that these responses are linear with average and marginal values being equal. A fundamental assumption when calculating employment multipliers is that employment level is tied to the amount of output generated.

As in the case of the GDP-output multipliers, we start by calculating the employment-output coefficients which are the ratios of the average full time employment (FTE) per sector to gross output per sector for a given year. Thereafter, we multiply the derived employment-output coefficients with the Leontief inverse to obtain either the Type I or Type II employment-output multipliers depending on whether the households are endogenized or not. The symmetric input-output data that we use in this work are denominated in million rubles, therefore, the obtained multiplier effects we need to understand in terms of a million rubles spent on amount of full-time jobs created. The employment-output coefficient describes the direct effect of an enhanced production stimulated by an additional million rubles worth of final demand for sector j on creation of additional FTE in sector j. The difference between the Type I employment-output multiplier for sector j and the employment-output coefficient for sector j gives the indirect effect that the expenditure of a million rubles on products and services of sector j has on FTE generation throughout the entire economy in order to produce the input requirements for sector j that are needed to satisfy the initial demand shock. The difference between the Type II and Type I employment-output multipliers for sector j estimates the induced effect the additional expenditure in million rubles on sector j's output has on creation of physical employment in the entire economy due to additional rounds of production that were necessary to satisfy the initial demand shock.

Figure 3.13 graphically portrays the direct, indirect and induced effects of FTE that are created per every million rubles spent on economic activity for years 1980-

2006. Appendix B, Table B.10 offers a full record of direct, indirect and induced effects with their relative rankings across the 27 years period. The industries with the top 10 Type II employment-output multipliers decomposed into direct, indirect and induced effects in terms of FTE created per million rubles of final demand are provided in Table 3.6.

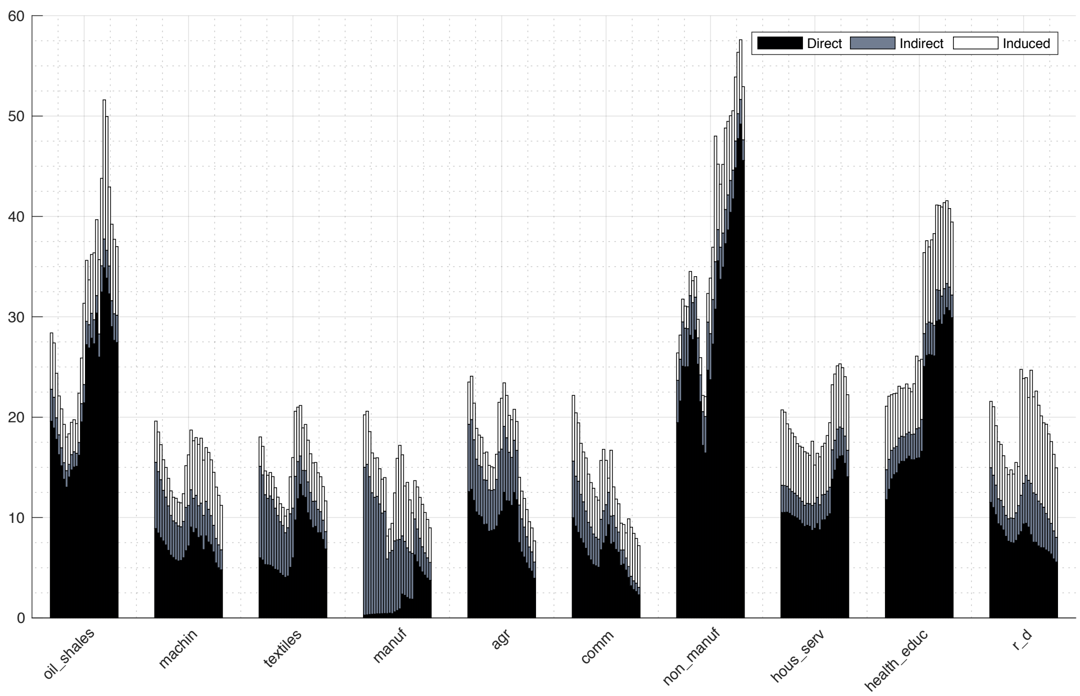


Note: Nomenclature in Appendix B, Table B.3

Figure 3.13: Type II employment-output multipliers by effect

In Figure 3.13 accompanied by Table 3.6 we can easily spot the three sectors with the highest Type II employment-output multiplier values – 'Other goods production' (abbreviated as non_manuf_serv), 'Other fuel production' (abbreviated as oil_shales), and public services (abbreviated as health_educ_serv). The 'Other goods production' sector is a composite of smaller, diverse in economic nature sub-industries: 'Procurement and distribution', 'Information services', 'Real estate operations', 'Geology and exploration works', 'Publishing services', 'Private security', and other business activities and production of goods. The full description of industries in the classification OKONh is available in Appendix B, Table B.2. Due to versatility of included economic activities within this sector, it is impossible to pin down which one drives the employment multiplier result. However, we can see that an additional spending of one million rubles for goods and services of this industry through direct, indirect, and induced effects on production creates 26 new full-time jobs in the economy. From Appendix B, Table B.10

we see that in 1980 19 full-time jobs are created directly in response to extra demand within the 'Other goods production' sector, 4 full-time jobs are created indirectly in other sectors of the economy due to inter-industrial linkages of this sector with the rest of the economy, and 3 full-time jobs are created within the economy as a result of satisfying the induced production stimulated by extra consumption of households. By 2006 this sector already created 53 FTE positions in the economy.



Note: Nomenclature in Appendix B, Table B.3

Figure 3.14: Top 10 Type II employment-output multipliers by effect

In general, we see that sectors with high employment-output coefficients (low gross labor productivity) and/or high Type II output multiplier effects have tendency to generate higher employment multipliers. Graphically, the top 10 sectors (with highest Type II multiplier median over 27 years) by type of effect are represented in Figure 3.14. If the Russian government would require to generate additional jobs in the economy, for example, in the attempt to reduce general unemployment level, the highlighted sectors will be the most responsive to the stimuli of extra expenditure. Here, of course, we assume in the tradition of the demand-driven input-output methodology that output and employment are demand-constrained. As can be seen in both Figure 3.13 and Figure 3.14, the majority of new employment in the top 10 sectors is created through direct channels (direct effects are significantly higher than indirect and induced effects), triggered by extra expenditure on output of these sectors. In fact, this is exactly what happened in the 1990s - early 2000s when the Russian government stimulated employment by creating low-level, low-productivity jobs in the non-market service sectors, e.g. janitors, cleaners. It inevitably led to over-saturation by people occupied in non-market services (over 30% of total labor force in 2000s) when compared to market economies with comparable income (Raiser Schaffer and Schuchhardt, 2004). Given the objective of the Russian government is to evolve in the direction of becoming a service-oriented market economy, it would be beneficial if the policy makers pay closer attention to the sectoral allocation of labor. More precisely, they should encourage the reallocation of labor towards high productivity sectors.

The general labor productivity of the economy during the Soviet episode of the studied period (1980-1990) increased only moderately by around 3% supporting the view of no differential productivity growth or sectoral reallocation of labor during that period. During the next five years (1991-1996) the average overall labor productivity declined by 8% almost uniformly across all sectors. However, most heterogenous changes in labor productivity across sectors occurred in the concluding decade (1997-2006). During this period the average productivity in agriculture increased by 12% even though the employment share in this sector fell from 15% to 6%. As we already mentioned, among more productive occupations there was an inflow of low-skilled jobs in the public service sectors which led to a decline by 2% in labor productivity in the public service sectors. The labor share in the public service sectors increased from 27% to 38%. In the years of 1997-2006 the labor shares in the industry and market services stayed approximately unchanged at 30% and 27% of total FTE, respectively, but the average labor productivity increased by 6%.

	Top multiplier by industry									
Year	1	2	3	4	5	6	7	8	9	10
1980	oil_shales	non_manuf_serv	agr_prod	comm_serv	r_d_serv	health_educ_serv	hous_serv	manuf_goods	machin	textiles
	28	26	24	22	22	21	21	20	20	18
1981	non_manuf_serv	oil_shales	agr_prod	health_educ_serv	r_d_serv	manuf_goods	hous_serv	comm_serv	machin	textiles
	28	27	24	22	21	21	21	20	19	17
1982	non_manuf_serv	oil_shales	health_educ_serv	agr_prod	comm_serv	hous_serv	r_d_serv	manuf_goods	machin	textiles
	32	24	22	21	19	19	19	19	17	15
1983	non_manuf_serv	health_educ_serv	oil_shales	agr_prod	hous_serv	r_d_serv	comm_serv	manuf_goods	machin	textiles
	31	22	22	19	19	18	17	16	16	14
1984	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	agr_prod	r_d_serv	comm_serv	manuf_goods	machin	textiles
	31	22	21	18	18	17	17	16	15	14
1985	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	agr_prod	r_d_serv	manuf_goods	comm_serv	textiles	machin
	35	23	19	18	18	16	16	16	14	14
1986	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	agr_prod	r_d_serv	manuf_goods	comm_serv	textiles	machin
	34	23	18	17	16	15	15	14	13	13
1987	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	agr_prod	r_d_serv	manuf_goods	comm_serv	textiles	machin
	34	23	18	17	17	14	14	13	12	12
1988	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	agr_prod	r_d_serv	manuf_goods	comm_serv	machin	textiles
	30	23	19	17	15	15	14	13	12	11
1989	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	agr_prod	r_d_serv	comm_serv	machin	textiles	constr
	26	23	20	17	15	14	12	12	11	10
1990	health_educ_serv	non_manuf_serv	oil_shales	hous_serv	r_d_serv	agr_prod	comm_serv	machin	textiles	constr
	23	22	19	16	15	15	12	11	10	10
1991	health_educ_serv	oil_shales	non_manuf_serv	agr_prod	hous_serv	comm_serv	r_d_serv	machin	textiles	constr
	23	22	22	16	16	16	15	12	11	11
1992	non_manuf_serv	health_educ_serv	oil_shales	r_d_serv	agr_prod	hous_serv	comm_serv	machin	constr	textiles
	32	26	26	25	21	18	17	15	14	14
1993	non_manuf_serv	oil_shales	health_educ_serv	r_d_serv	agr_prod	machin	wood	textiles	manuf_goods	comm_serv
	34	31	26	24	22	16	16	16	16	16
1994	non_manuf_serv	oil_shales	health_educ_serv	r_d_serv	agr_prod	textiles	wood	machin	manuf_goods	coal
	37	36	26	24	23	21	20	19	17	16
1995	non_manuf_serv	health_educ_serv	oil_shales	agr_prod	r_d_serv	textiles	machin	wood	comm_serv	coal
	48	36	34	22	22	21	18	17	17	17
1996	non_manuf_serv	health_educ_serv	oil_shales	r_d_serv	textiles	agr_prod	wood	machin	hous_serv	coal
	45	38	36	25	21	20	19	18	17	17
1997	non_manuf_serv	health_educ_serv	oil_shales	r_d_serv	agr_prod	textiles	wood	hous_serv	machin	constr
	43	37	36	22	20	19	18	17	17	17
1998	non_manuf_serv	oil_shales	health_educ_serv	r_d_serv	agr_prod	textiles	hous_serv	machin	coal	constr
	45	40	38	23	21	19	18	18	17	17
1999	non_manuf_serv	health_educ_serv	oil_shales	r_d_serv	agr_prod	hous_serv	textiles	coal	constr	machin
	49	38	36	21	20	19	18	17	16	16
2000	non_manuf_serv	oil_shales	health_educ_serv	hous_serv	r_d_serv	coal	machin	textiles	trans	agr_prod
	49	44	41	23	20	18	17	16	15	14
2001	oil_shales	non_manuf_serv	health_educ_serv	hous_serv	r_d_serv	coal	machin	textiles	trans	build_mat
	52	50	41	24	19	17	16	15	14	14
2002	non_manuf_serv	oil_shales	health_educ_serv	hous_serv	r_d_serv	coal	machin	textiles	build_mat	trans
	51	50	41	25	19	16	16	15	13	13
2003	non_manuf_serv	oil_shales	health_educ_serv	hous_serv	r_d_serv	coal	machin	textiles	fin_serv	build_mat
	54	43	41	25	18	15	15	14	12	12
2004	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	r_d_serv	textiles	coal	machin	fin_serv	build_mat
	56	42	39	25	18	14	13	13	12	12
2005	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	r_d_serv	textiles	coal	machin	fin_serv	elec
	58	41	38	24	16	13	12	12	12	11
2006	non_manuf_serv	health_educ_serv	oil_shales	hous_serv	r_d_serv	coal	textiles	machin	fin_serv	elec
	53	39	37	22	15	12	12	11	11	11

Table 3.6: Top 10 Type II employment-output multipliers for 1980-2006

3.5.5 Potential extensions

In this chapter we calculated several types of input-output multipliers with the intension of studying the sectoral interconnections in the Russian economy and understanding the structural change the country underwent during its transition. However, there are numerous ways to extend the framework to more specialized research needs. We will name just a few.

Two extensions to the existing framework are presented in the next chapter. There we incorporate a satellite account of carbon emissions into otherwise traditional Leontief model. It allows us to re-distribute the direct emissions through interindustrial linkages to the sectors responsible for their generation. With that, we can determine which sectors have the highest polluting effects and offer policy recommendations. We then use the environmentally extended input-output model to perform a structural decomposition analysis of emission changes over the period of 1992-2013, where we decompose the emission changes into six distinct components, i.e. drivers of these emissions. A detailed overview of both methods is given in the next chapter.

Currently, Russian national accounts do not explicitly identify any renewable energy sectors. Another possible extension to the existing model is to introduce a new renewable sector, i.e. wind, solar, and estimate an impact of investment into such a sector on, for example, job creation. Miller and Blair (2009, p. 633) describe two analytical approaches on how a new industry can be modeled. Malik et al. (2014); Garrett-Peltier (2011, 2017) provide a detailed coverage with application to energy industry.

Another interesting case would be to extend the environmental input-output framework even further to assess the impact of the pollution effects done by the economy on the quality of health. There is a certain need for this kind of research due to Russia's strong involvement in excavation of fossil fuels, metals, and other natural resources. An example of such application can be found in Vargas and Dietzenbacher (2012).

These are only few possible applications that can be done to the traditional input-output model. Novel ideas in the area of input-output analysis are regularly published in the peer-review journal 'Economic Systems Research'. All the fundamentals and extensions in the field up to the year 2009 can be found in Miller and Blair (2009).

3.6 Conclusion

The main objective of this work is to complete a detailed study of the production structure of the Russian economy while accounting for the inter-industrial linkages and track the evolution of the structural (technological) change in the period of 1980-2006. To accomplish this objective we utilize the demand-driven input-output modeling framework. The main attractive feature of the input-output framework is the ability to track the interlinkages between sectors of the economy. Via the notion of input-output multipliers it is analytically possible to disentangle the effects that an exogenous demand change in one industry has on the entire economy.

In the course of this chapter we derive several types of input-output multipliers. These are the Type I and Type II output, GDP-output, employment-output multipliers that describe the direct, indirect, and induced effects in terms of output, value added, and employment generation in the economy in response to an incremental increase in the final demand for a given sector's output. Other types of input-output multipliers considered in this work are the net output, the net value added, and the accounting output multipliers. The net multipliers controlling for the industry size identify whether a given sector is more important for the rest of the economy in terms of overall generated output or value added than the rest of the economy for this sector. The accounting output multipliers account for the relative size of an industry and for the activity supported by an industry's final demand, thereby by comparing the results across all industries it is possible to say which industry is more important in terms of the ability to stimulate the largest share of total output in the economy through direct and indirect linkages with other industries while satisfying its final demand.

We find that in the beginning of the studied period the 'Machinery' sector and other manufacturing sectors were of most importance in the Russian economy where controlling for their size they exhibited the largest ability to stimulate additional production in all other sectors of the economy than other sectors within the manufacturing sectors. However, all throughout the transition period the importance of these sectors continuously declined. Alongside the declining dominance of the manufacturing sectors we see a rising importance of service-oriented sectors such as 'Trade', 'Financial services', business, and public services. These results support the common view about the direction of the structural change while transitioning from a planned to a market economy[11]. For example, Doehrn and Heilemann (1996) find that by 1988 manufacturing was oversized in many Socialist countries, whereas services were small and underdeveloped. They projected a substantial shift of economic activity from manufacturing to services after the dissolution of the union. In this chapter we find an empirical support to this prediction. The input-output methodology enables to study the size and strength of the backward linkages, interrelations between the sectors of the Russian economy. It allows to examine the structural change that Russia was undergoing in the period right before and following the dissolution of the Soviet Union on a finer level.

Overall, we can see that the production structure of the Russian economy (characterized by the strength of the backward linkages) remains energy-intensive, however, there is a shift from specialization in manufacturing during the Soviet period towards specialization in production of raw natural resources such as oil and (ferrous and non-ferrous) metals in the latter years. However, starting late 1990's the strength of the backward linkages of such service oriented sectors as 'Trade', 'Research and development', 'Financial services', and 'Communal and (market) consumer services' grows significantly in size relative to other sectors of the economy. These sectors also exhibit growing labor productivity. Investing in development of these sectors could spur economic growth and help move Russia closer to becoming a market economy. In the meantime, the additional employment that was created was in non-market services where the share of employment reached 38% in 2006. This number is by over 10 percentage points higher than in an average market economy (Raiser Schaffer and Schuchhardt, 2004). Given the fact that the new employment has been predominantly created for low-wage, low productivity labor (e.g. cleaners, janitors, low skilled hospital and school workers), there is a missed opportunity in developing human capital that could further stimulate the economy. When calculating the accounting output multiplier measures we decomposed the final demand on domestic and foreign, we observed that the majority of activity stimulated by domestic final demand falls on such industries as 'Construction', 'Food', 'Agriculture', 'Transportation', whereas the activity in such sectors as 'Oil extraction', 'Oil processing', 'Non-ferrous metals', 'Ferrous metals' is predominantly driven by for-

[11] Doehrn and Heilemann (1996); Raiser Schaffer and Schuchhardt (2004); Lazarev and Gregory (2007); World Bank (2008).

eign final demand.

The input-output modeling framework is a standard methodology for examining the inter-relationships between sectors of the economy and final demand (Miller and Blair, 2009). The inherent assumptions of the framework allow to create a transparent linear system that is relatively easy to use and interpret. In particular, the assumption of only the demand having a real effect on the economy rules out any meaningful analysis of market that are characterized by scarcity and relative price endogeneity (Miller and Blair, 2009). Also, need to keep in mind that the supply side of the economy remains passive in the Leontief framework. Therefore, if the objective is to estimate the proper response to supply-side policies, a computable general equilibrium or other modeling frameworks need to be utilized. However, if an interest lies in estimating the response by industries to a demand-side policy actions accounting for the average inter-industrial relationships for a given year then the demand-driven input-output modeling framework is the properly chosen tool.

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Chapter 4

A Single-Region Structural Decomposition Analysis of Embodied Emissions: Evidence from Russia

4.1 Introduction

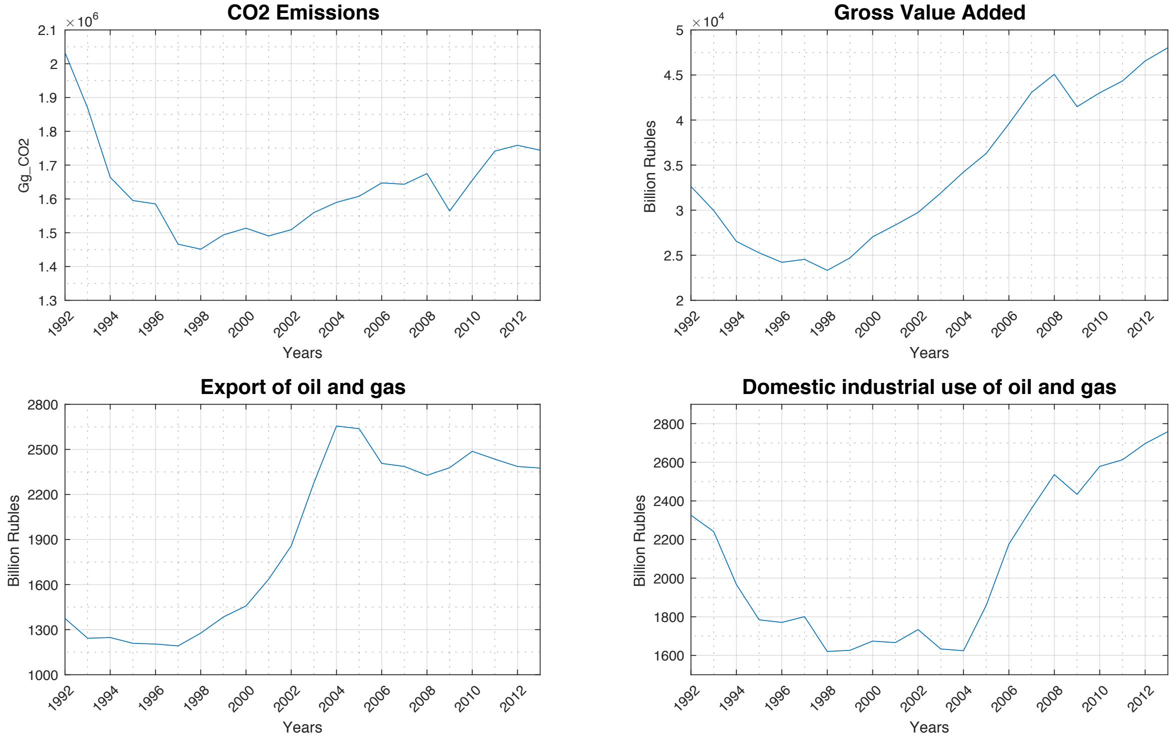
The 21st Conference of Parties in Paris (COP 21) in late 2015 released a call for worldwide action toward keeping global temperature rise at below 2°Celsius this century. The commitments held in place by the world economies prior to COP 21 were insufficient to meet this target (UNFCCC, 2016a). As one of the leading global energy producers, Russia is a major contributor to anthropogenic greenhouse gas emissions (IEA, 2014; BP, 2018). As of 2015, Russia held the fourth place in the world by total released greenhouse gas emissions –accounting for 5% of the world's total emissions (EDGAR, 2017). In 2015, Russian authorities submitted the Intended Nationally Determined Contributions (INDC) pledge which states that Russia is committed to reduce anthropogenic greenhouse gas emissions by 20-25% of the 1990 level by the year 2020 and by 25-30% of the 1990 level by the year 2030 (CarbonBrief, 2018).

In this work, we study the drivers of energy-related carbon dioxide (CO_2) emission changes in Russia over the period 1992-2013. We decompose the CO_2 emission changes into six effects: the emission coefficient effect, the energy mix effect, the energy intensity effect, the (Leontief structure) production technology effect, the final demand structure effect, and the total final demand effect. We find that Russia appears to be on track to meet its 2020 pledge but the economy needs to undergo some adjustments via diversification of production (revenue sources) and modernization of the environmental aspects of production technology in order to meet its 2030 pledge. Since the early 2000s, the Russian economy exhibits increased production and energy efficiency. However, the environmental aspect within the production technology started to exhibit signs of deterioration since 2008. The economy remains highly susceptible to demand shocks. To our knowledge, Russian emission changes have been studied only in the multi-region setting[1], but not in the single-region setting. The multi-region studies predominantly are concerned with the assessment of the effects embodied in trade, consumption choices (Wiedmann et al., 2007). The aim of this chapter is to study the energy-related CO_2 emissions from Russian production, i.e. producer responsibility, driven by the fact that the COP 21's call to reduce country-based emissions is still based on the amount of direct greenhouse gas emissions released by the country's production structure and not from the consumption of good and services. Also, Russia is a country net exporter mostly of energy-intensive commodities (i.e., fossil fuels, metals). Therefore, concentrating on addressing the Russian production emissions in the single-country setting would likely be more beneficial for the global emissions abatement.

This study takes a closer look at Russian emissions embodied in trade. According to BP (2018), in 2017 Russia remains the world's largest exporter of oil (12.7% of the total) and natural gas (20.4% of the total). Figure 4.1 plots Russian direct CO_2 emissions, gross value added, domestic intermediate and foreign consumption of oil and gas resources in 1992-2013. Note that the trend of carbon emissions roughly approximates the trend of the GDP, which closely follows the trends of export demand and domestic intermediate demand for oil and gas.

According to Russian Federal Treasury (2018) and Balance of Energy Resources

[1] Sun (1998); Xu and Dietzenbacher (2014); Lan et al. (2016); Wang et al. (2017a).



Source: CO2 emissions - Eora database, rest - IEF input-output data

Figure 4.1: Relation of CO_2 emissions, GVA, and demand for oil and gas

(2005-2015), the revenues from oil and gas sales have comprised almost half of the total federal budget sum for the past decade, of which the split between the domestic and foreign shares stayed approximately the same at 60%/40%[2]. Due to the subsequent price drop of both resources on the world market, the revenue declined to 43% of the federal budget in 2016 (Russian Federal Treasury, 2018). Since the Russian budget depends strongly on sales of oil and gas, it fluctuates with demand. Moreover, this dependence points at a dominance of fossil fuels in the energy mix of an economy being governed by energy and carbon intensive production.

The input-output structural decomposition analysis (SDA) technique is designed to distribute a change in an aggregate indicator into a pre-defined number of effects based on the input-output model (Lenzen, 2016; Lan et al., 2016). The SDA technique was first employed in the 1970s, in studies that measured sources of changes in some element of the input-output model (total output, value added, trade). The impacts of

[2]Detailed statistics on quantities and revenues from oil and gas sales from 2005 to 2015 are available in Appendix C, Table C.1.

demand and production technology on the economy were estimated when the aggregate indicator was generally decomposed into three distinct components. Since the 1980s, SDA has been applied to many energy studies (Gowdy and Miller, 1987; Rose and Chen, 1991), and, since around 2000, it has become an increasingly popular tool to study change in emissions. Depending on the choice of the SDA method - additive or multiplicative, the estimated aggregate indicator can be formulated in terms of quantity or in terms of intensity. An extensive literature is dedicated to calculating the effects of emission changes in both additive and multiplicative setting[3]. The additive method is more frequently used in practice mainly because it allows for an easier interpretation of the decomposition effects and is more adaptable to the studies involving Leontief inverse. We employ an additive SDA technique in this chapter.

The remainder of the chapter is structured as follows. Section 4.2 provides a detailed overview of data sources, assumptions, data processing and adjustment techniques. Section 4.3 describes the IO and SDA methodology with underlying properties and reviews the literature. Section 4.4 provides a socio-economic and direct emission background coverage. Section 4.5 is dedicated to a discussion of the direct and embodied CO_2 emissions and the SDA results of embodied CO_2 emissions. Section 4.6 concludes the discussion.

4.2 Data

In this chapter, we use data from the Institute of Economic Forecasting, RAM (henceforth, IEF, `macroforecast.ru`), a subsidiary of the Russian Academy of Sciences, that follows the Russian Economic Activities Classification System, version 1.1 (OKVED). The OKVED classification is consistent with the international national accounting standards, i.e., the Statistical Classification of Economic Activities in the European Community (NACE 1.1) and the International Standard Industrial Classification, revision 4 (ISIC Rev.4). The consistency of the industrial (and product) classification allows to apply environmental and energy use satellite data published by

[3]Sun (1998); Dietzenbacher and Los (1998); Hoekstra and van der Bergh (2003); Ang et al. (2003, 2004a); Lenzen (2006); Xu et al. (2011); Su and Ang (2012); Xu and Dietzenbacher (2014); Lenzen (2016); Lan et al. (2016); Wang et al. (2017a,b); Su et al. (2017).

international sources to Russian input-output data. Note that the Russian national statistical service does not publish environmental and energy use data by economic activity.

The analysis in this chapter is focused on emission drivers during the period 1992-2013. To achieve this objective, we choose to utilize input-output tables for five years 1992, 1996, 2000, 2008, and 2013. Hence, we divide the period of interest 1992-2013 into 4 sub-periods: 1992-1996, 1996-2000, 2000-2008, and 2008-2013. By decomposing the aggregate emission change for each of these time sub-periods into six distinct effects, we are able to understand which among the pre-defined effects contributes to emissions and which reduces them.

The choice of the years can be explained as follows. The year 1992 is the first year following the dissolution of the Soviet Union for which the output deflators and emission data become available. In the first half of the 1990s, the Russian economy underwent a rapid change in its restructuring towards becoming a market economy (i.e., the privatization of the state property, the emergence of new types of institutional units and statistical guidelines, the establishment of service sectors, the evolution of new market principles). As a consequence of inherited problems from the Soviet era plus newly acquired ones during the transition, the Russian economy went into recession. In this chapter we are interested to study the long-term emission drivers rather than short-term fluctuations. Hence, we avoid including years that fall in the midst of recessions. By the year 1996 the initial period of transition from a planned to a market economy was finalized, therefore this year is included in the sample. The structure of the economy became closer to that of a developed country, the inflation has been stabilized[4]. The third included year is 2000, which marks the end of the second recession period in the 1990s, the 1998 Russian financial crisis. The year 2008 marks the start of the Great Recession, and the year 2013 is the year leading up to the Ukrainian crisis of 2014 and the start of economic sanctions.

The original data is in basic constant 2010 prices. The economy is divided into 44 sectors[5]. Su et al. (2010) show that when conducting empirical input-output studies of

[4]If we choose the year 1997 instead of 1996, the year 1999 instead of 2000, and the year 2007 instead of 2008, the results of the decomposition change only marginally. The derived conclusions remain unaffected. We proceed with the years 1996, 2000, and 2008.

[5]We omit the 45th sector "Products and services by households" as it only contains zeros.

estimating energy-related CO_2 emissions embodied in (but not limited to) exports 40 economic sectors appear to capture the overall share of emissions embodied in exports. Based on this finding, we expect that the IEF data with sectoral aggregation of 44 will provide a solid estimation of energy-related CO_2 levels embodied in Russian exports and other final demand categories.

When it comes to constructing an input-output table, there are two approaches to the treatment of imports (Miller and Blair, 2009). The first approach is based on the non-competitive imports assumption, which treats imported commodities as different to domestic commodities of the same kind. The vast majority of OECD countries uses the non-competitive imports assumption (Su and Ang, 2013). The second approach is based on the competitive imports assumption, and it assumes that domestic and imported commodities of the same kind are produced using similar technology. The notable representatives who use the competitive imports approach are Russia, the USA, and China. The United Nations (2003) argues that the competitive imports assumption is unrealistic and advices to use the domestic transactions matrix when estimating (environmental) multipliers. Su and Ang (2013) show analytically that the estimate of emissions using the competitive imports assumptions is larger than those obtained using the non-competitive imports assumption, and the difference between the two embodiment estimates is driven by uncertainty incorporated in the estimate of emissions embodied in imports for intermediate consumption. Su and Ang (2013) also conclude that the emission technologies associated with different countries' products are unlikely to be the same. The difference in treatment of the two imports assumptions is summarized in Tables 4.1 and 4.2.

	Intermediate transactions	Final demands	Total output
Intermediate inputs	$\mathbf{Z_d}$	$\mathbf{y_d} + \mathbf{y_e}$	$\mathbf{x}$
Imports	$\mathbf{Z_i}$	$\mathbf{y_i}$	$\mathbf{y_m} = \mathbf{Z_i} \times \mathbf{1} + \mathbf{y_i}$
Value added	$\mathbf{v}'$		
Total inputs	$\mathbf{x}'$		

Table 4.1: Structure of the input-output table with non-competitive imports assumption

In Table 4.1, domestic ($\mathbf{Z_d}$) and imported ($\mathbf{Z_i}$) transactions are represented as separate matrices indicating incompatibility of the underlying production technology. In

	Intermediate transactions	Final demands	Imports	Total output
Intermediate inputs	$\mathbf{Z} = \mathbf{Z_d} + \mathbf{Z_i}$	$\mathbf{y_f} + \mathbf{y_e} = (\mathbf{y_d} + \mathbf{y_i}) + \mathbf{y_e}$	$-\mathbf{y_m}$	$\mathbf{x}$
Value added	$\mathbf{v}'$			
Total inputs	$\mathbf{x}'$			

Table 4.2: Structure of the input-output table with competitive imports assumption

Table 4.2 only the sum of domestic and imported inputs is available in the form of a single matrix ($\mathbf{Z}$). The final demand is also treated differently. Under the non-competitive imports assumption the vector of imports for final consumption ($\mathbf{y_i}$) is represented separately, but under the competitive imports assumption it is combined with the values of domestic final consumption ($\mathbf{y_d}$). Su and Ang (2013) show that under the non-competitive imports assumption the estimate of emissions embodied in exports only accounts for domestic emissions, while under the competitive imports assumption the estimate of emissions embodied in exports includes domestic emissions as well as imported emissions to intermediate consumption. Therefore, to be precise in estimating the embodied emissions in this chapter, we extract the imported share of intermediate inputs ($\mathbf{Z_i}$) and final demand ($\mathbf{y_i}$) following Su et al. (2010).

The following formulas are used to extract imports from the input-output data with the competitive imports assumption:

$$s_i = \frac{y_{m,i}}{x_i + y_{m,i} - y_{e,i}}, \quad \mathbf{A_i} = \hat{\mathbf{s}} \times \mathbf{A}, \quad \mathbf{y_i} = \hat{\mathbf{s}} \times \mathbf{y_f}, \tag{4.1}$$

where s_i is the share of imports in the supply of products and services to each sector i, $y_{m,i}$ is the vector of the domestic imports for sector i, $y_{e,i}$ is the vector of the domestic exports for sector i, x_i is the total output for sector i, $\mathbf{A_i}$ is the imported matrix of technical coefficients[6], and $\mathbf{y_i}$ is the vector of direct imports for domestic consumption. The 'hat' notation signifies diagonalization.

[6] We cover methodology in Section 4.3. The domestic technical coefficients and domestic final demand matrices are obtained as $\mathbf{A_d} = (\mathbf{I} - \hat{\mathbf{s}})\mathbf{A}$ and $\mathbf{y_d} = (\mathbf{I} - \hat{\mathbf{s}})\mathbf{y_f}$.

4.2.1 Emissions data

This chapter restricts analysis to energy-related CO_2 emissions. We extract production emissions by sector from the Eora multi-region input-output database (Eora MRIO, `www.worldmrio.com`) for Russia and harmonize them to the sectoral aggregation level of the IEF data.

The Eora MRIO database is an open-access statistical data source developed by the research group at the University of Sydney in 2012. The database specializes in detailed trade, emissions and energy use accounts. Information on the construction, sensitivity analyses, and characteristics of the database can be found in Lenzen et al. (2013). With respect to this chapter, there are two attractive features in favor of using this data source. The first feature is the sectoral detail level of the satellite accounts (emissions and energy use), with a total of $n = 47$ sectors. The detail level of e.g. the world input-output database (WIOD) is $n = 35$ sectors. It is easier to integrate the Eora satellite accounts with sectoral level of $n = 47$ towards $n = 44$ in order to match the IEF data. The second attractive feature is the historical coverage. The CO_2 emissions satellite account for Russia covers the period 1992-2013. The energy consumption satellite has an even longer time span. Lastly, the level of transparency of the database is appealing. The research group routinely conducts sensitivity analyses, which are all publicly available.

The main data source for the environmental and energy consumption satellite accounts for Russia in the Eora database is the International Energy Agency (IEA). The emissions are grouped in the Eora database according to the Emissions Database for Global Atmospheric Research (EDGAR) classification scheme developed by the European Commission (EDGAR, 2017). This chapter uses CO_2 emissions satellite account that is classified as the emissions generated in the process of energy production. According to Marland (2008), the IEA relies on the IPCC methodologies and states that for countries with good energy collection methods an uncertainty in the emissions calculations will range +- 5%. The uncertainty range in countries with less developed energy data systems, of which Russia is a part, is +-10%.

Both the Eora and the IEF databases are based on the ISIC industrial classification, which means the direct synchronization of the input-output data with the satellite accounts can be achieved analytically. The Eora dataset offers more detailed representation of the IEF's 'Production and distribution of electricity, gas and water' and 'Transportation and storage' sectors. We simply sum across these additional Eora sectors to bring the data to the necessary sectoral level. To synchronize the energy production sectors, we disaggregate the Eora's 'Mining and quarrying (energy)' sector into 4 IEF energy sectors 'Oil production', 'Gas production', 'Coal production', and 'Other fuel production'. Following Su et al. (2010), we weigh these 4 sectors by their output in current prices. More specifically, the weights are $w_{gas} = \frac{x_{gas}}{x_{oil}+x_{gas}+x_{coal}+x_{other}}$, $w_{oil} = \frac{x_{oil}}{x_{oil}+x_{gas}+x_{coal}+x_{other}}$, $w_{coal} = \frac{x_{coal}}{x_{oil}+x_{gas}+x_{coal}+x_{other}}$, and $w_{other} = \frac{x_{other}}{x_{oil}+x_{gas}+x_{coal}+x_{other}}$. The weights are then multiplied by the total emissions of the 'Mining and quarrying (energy)' sector to obtain the necessary level of disaggregation.

4.3 Methodology

To properly estimate the national environmental responsibility, Su and Ang (2013) advocate using the domestic production technology matrix in the national environmental input-output analysis. After we separate domestic and imported inputs and final demand accounts using the procedure described in Section 4.2, we can formulate the standard input-output model under the non-competitive imports assumption:

$$\mathbf{x} = \mathbf{Z_d} \times \mathbf{1} + (\mathbf{y_d} + \mathbf{y_e}) = \mathbf{A_d}\mathbf{x} + (\mathbf{y_d} + \mathbf{y_e}) \tag{4.2}$$

where $\mathbf{x}$ is an $n \times 1$ vector of total output with n number of sectors in the economy, $\mathbf{Z_d}$ is a $n \times n$ matrix of domestic intermediate inputs, $\mathbf{y_d}$ and $\mathbf{y_e}$ are the $n \times 1$ vectors of domestic and foreign final demands. The matrix of domestic intermediate inputs can be further used to calculate the domestic production coefficients, $\mathbf{A_d} = \mathbf{Z_d}\hat{\mathbf{x}}^{-1}$, which measure the fixed relationships between sectoral output and its inputs.

After ensuring non-singularity of $(\mathbf{I} - \mathbf{A})$, equation 4.2 can be re-written in the form of the Leontief identity:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A_d})^{-\mathbf{1}}(\mathbf{y_d} + \mathbf{y_e}) = \mathbf{L_d}(\mathbf{y_d} + \mathbf{y_e}) \tag{4.3}$$

where $\mathbf{L_d} = (\mathbf{I} - \mathbf{A_d})^{-1}$ is the $n \times n$ domestic Leontief inverse matrix. The Leontief inverse matrix quantifies direct and indirect (embodied) input requirements of each sector in the economy for production of a unit of sectoral output. The domestic final demand ($\mathbf{y_d}$) can also be represented in the form of a matrix of various domestic final demand sub-categories such as household consumption ($\mathbf{y_{pc}}$), government consumption ($\mathbf{y_{gc}}$), gross fixed capital formation ($\mathbf{y_{gfcf}}$), and change in inventory ($\mathbf{y_{ci}}$).

This standard input-output model can be further extended to estimate the total amount of CO_2 emissions per unit of value of a sector's output (C_{tot}).

$$\begin{aligned} C_{tot} &= \mathbf{f'x} = \mathbf{f'(I - A_d)^{-1}(y_d + y_e)} = \mathbf{f'L_d(y_d + y_e)} \\ &= \mathbf{f'L_d(y_{pc} + y_{gc} + y_{gfcf} + y_{ci} + y_e)} \\ &= C_{pc} + C_{gc} + C_{gfcf} + C_{ci} + C_e \end{aligned} \tag{4.4}$$

where $\mathbf{f} = \mathbf{cx}^{-1}$ is a $n \times 1$ vector of emission coefficients, and $\mathbf{c}$ is a $n \times 1$ vector of sectoral CO_2 emissions.

4.3.1 Structural Decomposition Analysis

Structural decomposition analysis (SDA) distributes a change in an aggregate indicator into a number of components that are individually associated with a predefined factor based on an input-output model (Wang et al., 2017b). A set of decomposition components are mutually exclusive and collectively exhaustive (Lenzen, 2016). SDA splits the environmental input-output model, such as depicted in equation 4.4, into an exhaustive sum of changes in components such as emission technology ($\mathbf{f}$), production technology ($\mathbf{L}$), and final demand ($\mathbf{y}$).

SDA is a generalization of index decomposition analysis (IDA) to matrix variables (Hoekstra and van der Bergh, 2003). SDA was first applied in the 1970s to determine changes in the components of interest of the input-output model, e.g. total output, and total value added (Su and Ang, 2012). Since the 1980s, the SDA started to be applied to energy studies (Gowdy and Miller, 1987; Rose and Chen, 1991). Since 2000, SDA has been consistently applied to studies of CO_2 emission drivers (Su and Ang, 2012).

There are two variants of SDA - an additive and a multiplicative (Rose and Casler, 1996). Within energy and emission studies the additive SDA is the most common (Wang et al., 2017b). The explanation for such widespread use of the additive SDA can be reduced to the ease of mathematical handling and convenience of interpretation. There is a number of recent studies that utilize an additive SDA, investigating growth of individual country's energy use and emissions[7]. Until the Paris Agreement in late 2015, all of the pledges of countries were in a quantitative form which again offers an explanation as to why the additive form of SDA is frequently used. Approximately 90% of English-language, peer-reviewed journal articles on SDA applied to energy and emissions from 2010 to 2016 are completed using the additive SDA form (Wang et al., 2017b). Since the Paris Agreement, some countries, e.g. China and Japan, shifted to commitments in relative terms against some base year, which explains an emergence of popularity of the multiplicative SDA in studies in 2017.

As Lenzen (2016) notes, the basic additive decomposition form of a function $f(x_1, x_2, ..., x_n)$ of n temporally varying arguments $x_i(t)$ is its total differential $df = (\delta f/\delta x_1)dx_1 + (\delta f/\delta x_2)dx_2 + ... + (\delta f/\delta x_n)dx_n$. Each component of the equation represents a contribution of that argument to the aggregate change. For a special case function when $f(x) = \prod_{i=1}^{n} x_i$, the total differential simplifies to $df = \sum_{i=1}^{n}(\prod_{j=1,i\neq j}^{n} x_j dx_i)$. Hence, the environmental Leontief decomposition identity equation can be written as:

$$\begin{aligned} \Delta C_{tot,*} &= \mathbf{f'^t L_d^t y_*^t} - \mathbf{f'^0 L_d^0 y_*^0} = \mathbf{df' L_d y_*} + \mathbf{f' dL_d y_*} + \mathbf{f' L_d dy_*} \\ &= \Delta C_{eint,*} + \Delta C_{lstr,*} + \Delta C_{y,*}, \end{aligned} \tag{4.5}$$

where $(*)$ signifies a final demand group, C_{eint} is the emission intensity effect, C_{lstr} is the Leontief structure effect, and C_y is the final demand effect. The aggregate effect of each individual sub-group is the summation of this effect across all final demand categories.

Further the decomposition can be represented determining the growth rate of the factor x_i as a linear change dx_i ("Laspeyres-linked" approach) or as a logarithmic change $d \ln x_i$ ("Divisia-linked" approach) (Ang, 2004b; Lenzen, 2006). The total differential

[7] which include Wood (2009); Xie (2014); Chang and Lahr (2016); Cansino et al. (2016); Supasa et al. (2016); Wu and Zhang (2016); Su et al. (2017).

of the function $f(x_1, x_2, ..., x_n)$ can be re-written as:

$$df = \frac{f(x_1, x_2, ..., x_n)}{x_1} dx_1 + \frac{f(x_1, x_2, ..., x_n)}{x_2} dx_2 + ... + \frac{f(x_1, x_2, ..., x_n)}{x_n} dx_n = \tag{4.6}$$

$$f(x_1, ..., x_n) d\ln x_1 + f(x_1, x_2, ..., x_n) d\ln x_2 + ... + f(x_1, x_2, ..., x_n) d\ln x_n$$

The first line of equation 4.6 depicts the "Laspeyres-linked" approach to decomposition and the second line represents the "Divisia-linked" approach. In the analysis of discrete time series, in order to obtain Δf one needs to integrate infinitesimal changes df. It can be formulated in the following manner:

$$\begin{aligned} \Delta f = \int_0^t df \quad &= \sum_{i=1}^{n} \int_0^t \frac{f(x_i)}{x_i} dx_i = \sum_{i=1}^{n} \left(\int_0^t \prod_{j=1, j \neq i}^{n} x_j dx_i \right) \\ &= \sum_{i=1}^{n} \int_0^t f(x_i) d\ln x_i = \sum_{i=1}^{n} \left(\int_0^t \prod_{j=1}^{n} x_j d\ln x_i \right) \end{aligned} \tag{4.7}$$

Again, the first line of equation 4.7 represents the "Laspeyres-linked" approach, whereas the second line depicts the "Divisia-linked" approach. The difference between the two approaches is that the former explains the change in terms of absolute changes of the sub-aggregates, while the latter refers to relative changes. To compute equation 4.7, the values for $\prod_{j=1,j\neq i}^{n} x_j$ and $\prod_{j=1}^{n} x_j$ have to be known in order to integrate variables x_i over the period $[0, t]$. An integral path, or a weight function, for $\prod_{j=1,j\neq i}^{n} x_j = f(x_i)$ has to be chosen (Shapley, 1953; Ang et al., 2003; Wang et al., 2017b).

Equation 4.7 can be re-arranged so that:

$$\begin{aligned} \Delta f = \sum_{i=1}^{n} \left(\prod_{j=1, j \neq i}^{n} x_j \int_0^t dx_i \right) \quad &= \sum_{i=1}^{n} \left(\prod_{j=1, j \neq i}^{n} x_j (x_i^t - x_i^0) \right) \\ \cong \sum_{i=1}^{n} \left(\prod_{j=1}^{n} w_{i,j}^L (x_i^t - x_i^0) \right) \quad &\cong \sum_{i=1}^{n} \left(\prod_{j=1}^{n} w_{i,j}^D \ln \frac{x_i^t}{x_i^0} \right), \end{aligned} \tag{4.8}$$

where $w_{i,j}^L = f(\bar{x}_i)^L / \bar{x}_{i,j}^L$ is the integral path used for the "Laspeyres-linked" approach, and $w_{i,j}^D = f(\bar{x}_i)^D$ is the integral path used for the "Divisia-linked" approach. Some common integral paths are presented in Table 4.3 (Wang et al., 2017b). One possibility for choosing the integral path is to assume a constant value throughout the changes in the x_i: $f(x_i) = \prod_{j=1,j\neq i}^{n} x_j = \text{const}$ (Lenzen, 2006). Possible choices for the constant are the parametric averages which yield the Laspeyres method decomposition if base weights are selected, the Paasche method decomposition if terminal weights are selected, and the Marshall-Edgeworth method decomposition if mid-point weights are selected. However, the Laspeyres and Paasche decompositions are never exact, they leave a residual, and the Marshall-Edgeworth decomposition is only exact for $n = 2$. The Divisia-linked AMDI decomposition method suffers from the same shortcoming. Another possibility is to assume an integral path with proportional change for all x_i. These are the Laspeyres-linked S/S-D&L and the Divisia-linked LMDI decomposition methods. We will cover them shortly. For a detailed treatment of each weight function refer to Hoekstra and van der Bergh (2003) and Lenzen (2006).

Category	Additive decomposition method	Weight function
Laspeyres-linked	Laspeyres method	$w^L_{i,j} = x^0_{i,1} x^0_{i,2} ... x^0_{i,n}$
	Paasche method	$w^L_{i,j} = x^t_{i,1} x^t_{i,2} ... x^t_{i,n}$
	Marshall-Edgeworth method	$w^L_{i,j} = x_{i,1}^{\frac{0+t}{2}} x_{i,2}^{\frac{0+t}{2}} ... x_{i,n}^{\frac{0+t}{2}}$
	S/S-D&L method	$w^L_{i,j} = \sum_{R=S-\{i\}}^{i \in S \subset N, \|S\|=s} \frac{1}{n} \frac{1}{C^{n-1}_{s-1}} f_i(R, \{j\})$
Divisia-linked	AMDI	$w^D_i = \frac{f^t_i + f^0_i}{2}$
	LMDI-1	$w^D_i = L(f^t_i, f^0_i)$
	LMDI-2	$w^D_i = \frac{L(f^t_i/f^t, f^0_j/f^0)}{\sum_i L(f^t_i/v^t, f^0_i/f^0)} L(f^t, f^0)$

[1] The S/S-D&L method denotes the Shapley/Sun method (Sun, 1998) in IDA and the additive D&L method (Dietzenbacher and Los, 1998) in SDA, they are identical in decomposition.
$f(S) = \sum_{i=1}^{n} \prod_{p \in S} x^t_{i,p} \prod_{q \in N-S} x^0_{i,p}, S \subset N$; $v_i(R, \{j\}) = \prod_{p \in R} x^t_{i,p} \prod_{q \in N-R-\{j\}} x^0_{i,q}, i \notin R$

[2] $L(a, b) = \frac{a-b}{\ln a - \ln b}$

Table 4.3: Weight functions for additive decomposition method

Many weight functions produce a residual as part of the decomposition. Omission of this residual effect can cause a substantial estimation error (Sun, 1998). To avoid this, a method should be used that ensures an ideal, complete decomposition. The properties of an ideal decomposition method are perfect decomposition, consistency in aggregation, robustness to negative/zero values, linkage between additive and multiplicative decompositions, and ease of use and interpretation (Su and Ang, 2012). The perfect decomposition property ensures that the decomposition leaves no residual term. The property of consistency in aggregation signifies that the decomposition sustains the time reversal test. That is, if the time period of the sub-aggregate effects were reversed, the decomposition returns the reciprocal result. The rest of the properties are self-explanatory from their name.

As represented in Table 4.3, the Laspeyres-linked weights can be represented by the Laspeyres index, the Paasche index, and the Shapley/Sun - Dietzenbacher & Los (S/S-D&L) index (Sun, 1998; Dietzenbacher and Los, 1998). The first two indices have been used in the energy consumption decomposition analysis in the 1970s and 1980s. Their use was discontinued because they leave a residual term in the decomposition. The S/S-D&L index, on the other hand, does not suffer from the same shortcoming. The S/S index is formulated for the index decomposition analysis (IDA), whereas the D&L index is unique to the SDA. Despite of the different origins and evolution, both indices arrive at the similar mathematical formulation (Hoekstra and van der Bergh, 2003). Contrary to the Laspeyres and the Paasche indices, the S/S-D&L index satisfies all of the desired properties[8].

As Ang et al. (2004a) note, in an n-factor decomposition the S/S-D&L approach completes $n!$ calculations of $(f^t - f^0)$ with subsequent derivation of the arithmetic average for each variable to generate an effect of each variable. All variables are treated proportionately. The sum across estimated effects yields the total effect.

According to Wang et al. (2017a), the majority of studies on energy or environmental additive SDA between 2010 and 2017 employed the additive Laspeyres-linked S/S-D&L method. Starting in 2012, there has been an uptake of Divisia-linked, particularly LMDI (Logarithmic Mean Divisia Index), methods. However, to date, only a few studies utilize this methodology. Su and Ang (2012) compare a number of additive decomposition methods and show that LMDI-1 and S/S-D&L methods are preferred for one-stage decomposition (without decomposition of the Leontief inverse matrix effects) and only the additive S/S-D&L method is recommended for two-stage decomposition (with decomposition of the Leontief structure effect). That is, because of the inverse matrix, the Leontief structure cannot be written in the form of index number theory. As a consequence, the Divisia-linked decomposition methods can no longer be applied. Only the Laspeyres-linked method is used as a 'one factor at a time' principle across

[8]The proof of perfect decomposition using the S/S-D&L method is available in Appendix C.

i, j dimension.

Going back to the environmental Leontief decomposition equation 4.5, the final demand component can be further decomposed into the final demand structure and the total final demand effect.

$$\begin{aligned} \Delta C_{tot,*} &= \mathbf{f'^t L_d^t} \Big(\frac{\mathbf{y_*^t}}{\mathbf{y^t}}\Big)\mathbf{y^t} - \mathbf{f'^0 L_d^0}\Big(\frac{\mathbf{y_*^0}}{\mathbf{y^0}}\Big)\mathbf{y^0} \\ &= \mathbf{df' L_d y_s y} + \mathbf{f' dL_d y_s y} + \mathbf{f' L_d dy_s y} + \mathbf{f' L_d y_s dy} \\ &= \Delta C_{eint,*} + \Delta C_{lstr,*} + \Delta C_{ystr,*} + \Delta C_{ytot,*}, \end{aligned} \tag{4.9}$$

where $\mathbf{y_s} = \frac{\mathbf{y_*}}{\mathbf{y}}$ is the structure of the final demand for a specified final demand category, $\Delta C_{ystr,*}$ is the final demand structure effect of the SDA, $\Delta C_{y,*}$ is the total final demand effect. The individual components by final demand category of the SDA are additive to represent the total effect of final demand.

$$\begin{aligned} \Delta C_{eint} &= \Delta C_{eint,pc} + \Delta C_{eint,gc} + \Delta C_{eint,gfcf} + \Delta C_{eint,ci} + \Delta C_{eint,ex} \\ \Delta C_{lstr} &= \Delta C_{lstr,pc} + \Delta C_{lstr,gc} + \Delta C_{lstr,gfcf} + \Delta C_{lstr,ci} + \Delta C_{lstr,ex} \\ \Delta C_{ystr} &= \Delta C_{ystr,pc} + \Delta C_{ystr,gc} + \Delta C_{ystr,gfcf} + \Delta C_{ystr,ci} + \Delta C_{ystr,ex} \\ \Delta C_{ytot} &= \Delta C_{ytot,pc} + \Delta C_{ytot,gc} + \Delta C_{ytot,gfcf} + \Delta C_{ytot,ci} + \Delta C_{ytot,ex} \end{aligned} \tag{4.10}$$

The emission intensity (ΔC_{eint}) and the Leontief production technology (ΔC_{lstr}) effects can be disaggregated further.

Su et al. (2017) suggests extracting additional effects through further disaggregation of the emission intensity, $\mathbf{f} = (f_i)_{n\times 1}$.

$$f_i = \frac{c_i}{x_i} = \sum_{j=1}^{k} \rho_j \frac{e_{ij}}{x_i} = \sum_{j=1}^{k} \rho_j \frac{e_{ij}}{e_i}\frac{e_i}{x_i} = \sum_{j=1}^{k} \rho_j s_{ij} g_i, \tag{4.11}$$

where c_i is sector i's carbon emissions, x_i is sector i's total output, k is the amount of different energy types, ρ_j is the emission coefficient of energy type j, e_{ij} is sector i's consumption of energy type j, e_i is sector i's total energy consumption, $s_{ij} = e_{ij}/e_i$ is sector i's energy use coefficient of fuel type j, and $g_i = \frac{e_i}{x_i}$ is sector i's energy intensity.

Given this additional layer of structural disaggregation, the emission intensity effect takes the following form:

$$\Delta C_{eint,*} = \Delta C_{ecof,*} + \Delta C_{emix,*} + \Delta C_{gint,*}, \tag{4.12}$$

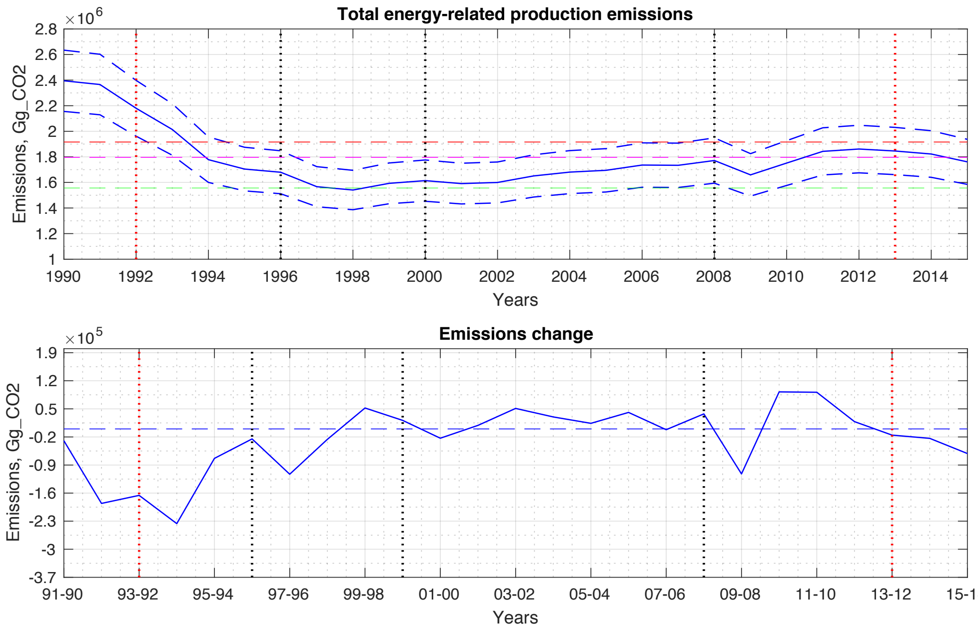
where $\Delta C_{ecof,*}$ is the emission coefficient effect of a final demand category, $\Delta C_{emix,*}$ is the energy mix effect, and $\Delta C_{gint,*}$ is the energy intensity effect. Analogous to equation 4.10, the cumulative function of these sub-effects across final demand categories sums up to the total emission intensity effect.

$$\begin{aligned} \Delta C_{ecof} &= \Delta C_{ecof,pc} + \Delta C_{ecof,gc} + \Delta C_{ecof,gfcf} + \Delta C_{ecof,ci} + \Delta C_{ecof,ex} \\ \Delta C_{emix} &= \Delta C_{emix,pc} + \Delta C_{emix,gc} + \Delta C_{emix,gfcf} + \Delta C_{emix,ci} + \Delta C_{emix,ex} \\ \Delta C_{gint} &= \Delta C_{gint,pc} + \Delta C_{gint,gc} + \Delta C_{gint,gfcf} + \Delta C_{gint,ci} + \Delta C_{gint,ex} \end{aligned} \tag{4.13}$$

The additional decomposition of ΔC_y and ΔC_{eint} effects allows for 6-factor SDA decomposition using the S/S-D&L weight function.

4.4 Background

Before we proceed with the structural decomposition, it is practical to briefly discuss the structure of the Russian economy. Russia is one of the major global fossil fuel producers and, consequently, one of the largest polluters (BP, 2018). First, we start by examining the trend of total energy-related CO_2 emissions over the period post the year 1990. Figure 4.2 depicts total energy-related CO_2 emissions (including direct emissions by households) and their annual change for Russia in Gigagrams of CO_2 equivalent (Gg-CO2). To better envision the trend of CO_2 pollution generation we include additional statistics for the years of 1990, 1991, 2014 and 2015 (the latest available) obtained from the EDGAR database (EDGAR, 2017). We separate the data for the supplementary years by the red vertical dotted lines. These data are introduced solely to provide a more complete summary of the Russian total CO_2 emissions. The four studied periods of 1992-1996, 1996-2000, 2000-2008, and 2008-2013 are separated by the black vertical dotted lines.



Sources: Eora; EDGAR.

Figure 4.2: Russia's carbon emissions portrait

We observe a rapid decrease in the amount of total CO_2 emissions during the 1990s with a subsequent steady modest rise over the next two decades and a relative flattening out at the mark of 1,800,000 Gg-CO2 by 2013, marking a reduction by 26% compared of the 1990 level. As mentioned earlier, the Russian INDC pledge aims to reduce total pollution by 20-25% from the 1990 level by the year 2020 (The Government of the Russian Federation, 2014). We assume the authorities are dedicated to reduce pollution in equal proportions for all greenhouse gases to meet the pledge. The red dashed horizontal line in Figure 4.2 marks the 20% below 1990 level, or approximately 1,900,000 Gg-CO2, and the magenta dashed horizontal line provides the 25% below 1990 level, or approximately 1,800,000 Gg-CO2. The green dashed line shows an expected reduction level of 35% by 2030, or approximately 1,550,000 Gg-CO2. The 10% uncertainty interval in Figure 4.2 accounts for uncertainty in reported Russian emission data, as discussed in Section 4.2.1.

If we assume the emissions would remain at the 2015 level, Russia is going to meet its target emission. This is true even when we account for 10% uncertainty in the data. Figure 4.2 depicts the entire uncertainty interval to be below the red 20% line. However, it is also clear that the Russian authorities will need to undertake additional measures if they intend to meet the 2030 goal, as currently the entire emission estimate lies above it.

Year	Population (Thousands)	Gross Value Added (Constant 2010 billion RUB)	Carbon emissions (Gg_CO_2)		
			Industry	Household	Total
1992	148,562	32,630.46	2,033,080	146,742	2,179,823
1996	148,029	24,217.16	1,585,169	94,448	1,679,617
2000	146,304	27,044.24	1,513,469	100,673	1,614,142
2008	142,737	45,075.21	1,675,000	96,371	1,771,371
2013	143,667	48,026.28	1,744,117	101,617	1,845,734

Source: ROSSTAT (2017).

Table 4.4: Socio-economic and emission indicators

Table 4.4 provides general socio-economic and emissions summary statistics for Russia. From 1992 until 2013, the population decreased by 3% while the gross value added increased by 47%. At the same time the total carbon emissions decreased by 15% from 2,179,823 Gg-CO2 to 1,845,734 Gg-CO2. The CO_2 emissions generated by the industry decreased by 14% from 2,033,080.3 Gg-CO2 to 1,744,116.6 Gg-CO2, and the household direct emissions decreased by 30% from 146,742.3 Gg-CO2 to 101,616.9 Gg-CO2. Much of this decrease can be attributed to the fall in production following the dissolution of the Soviet union. Nevertheless, the CO_2 emissions per unit of GDP decreased by 42% from 66.8 Gg-CO2 per BRub to 38.4 Gg-CO2 per BRub, which suggests a shift of the Russian economy towards less polluting and more profitable sources of economic activity. The per capita GDP increased by 52% in the studied period. Given that the share of the work force stayed approximately the same (around 70%) in 1992 and 2013, the fact that GDP per capita increased by such significant amount also points at increased labor productivity. Although total carbon emissions were reduced between 1992 and 2013, the year 2000 is a local minimum at 1,614,142 Gg-CO2. This level equates to a 26% reduction from the 1992 level, and 33% from the 1990 level.

Figure 4.3 depicts total direct emissions from fossil fuel combustion in Russia from

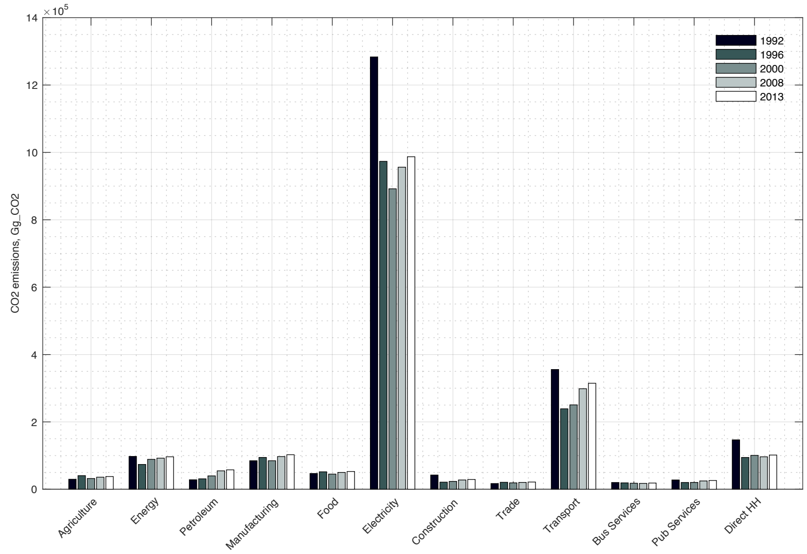


Figure 4.3: Total direct CO_2 emissions

1992 until 2013. To analyze the crosscut of the total emissions, we aggregate 44 sectors from the IEF tables into 11 sector groups. These groups are Agriculture, Energy production, Petroleum (oil refining) production, Manufacturing, Food production, Electricity generation, Construction, Trade, Transportation, Business services, and Public services. The Energy production group includes production of primary energy resources - oil, gas, coal, nuclear and other energy sources. To properly capture the effects of the investment outflow from the oil refining sector, we segregate this sector from other energy producing sectors. To account for total emission generation, we include direct household CO_2 emissions. As can be seen in Figure 4.3, production of electricity accounts for the vast majority of directly generated emissions, followed by transportation services, direct household emissions, energy production, and manufacturing. Despite the 15% decrease in the total emissions from 1992 to 2013, and the 23% decrease from 1990, after the initial drop in the 1990s the emissions are rising since the year 2000. From 2000 to 2013, the emissions increased by 14%. The rise in emissions since the year 2000 can be explained by a quick recovery in total production after the turbulent preceding decade. There were many contributing factors to the recovery, some of which include rising prices of fossil fuels which spikes energy exports, realization of underutilized in the 1990s production capacity, real exchange rate devaluation leading to import substitution effect, and domestic policy (World Bank, 2003).

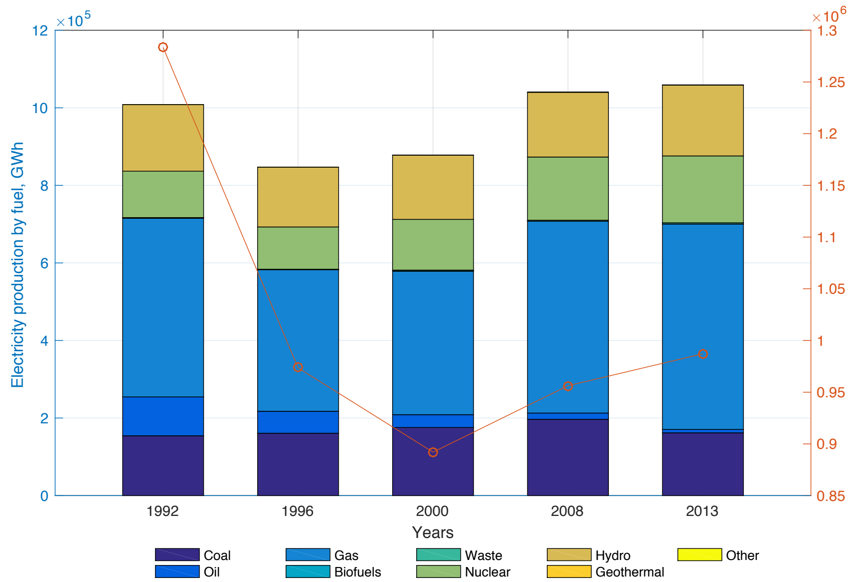
The structure of the total direct emissions changed only to a small degree throughout the period. The Electricity sector's share fell from 59% of total direct CO_2 emissions in 1992 to 55% in 2000 to 53% in 2013. The share of emissions originating in the transportation services stayed at the mark of about 17% as a share of total emissions. Of this share, an approximately equal amount of 43% respectively is generated by inland (including pipelines) and water transport, and 15% come from air freight. The remaining sectors are less pronounced with most prominent being direct household emissions (5-7%), manufacturing (4-6%), and energy production (4-5%).

Year	Oil	Gas	Coal	Peat	Oil shale	Fire wood	Other	Total	Total CO2 emissions (Gg_CO2)
1990	738.00	739.00	262.00	1.80	1.40	16.00	98.30	1,856.50	2,033,080.28
1996	431.00	694.00	170.00	1.40	0.50	7.00	91.10	1,395.00	1,585,169.12
2000	463.00	674.00	163.00	0.70	0.50	5.40	102.00	1,408.60	1,513,468.96
2008	698.00	766.00	212.00	0.30	0.20	4.40	114.00	1,794.90	1,674,999.47
2013	746.00	770.00	237.00	0.50	0	4.00	122.00	1,879.50	1,744,116.58

Sources: Russian Statistical Yearbook, Eora.

Table 4.5: Total primary energy production by fuel type, Mtoe

It is beneficial to check the evolution of the production of primary energy resources. Table 4.5 exhibits total primary energy production by fuel type in physical units. As expected, we observe a similar trend in production of fossil fuels with direct industrial carbon emissions. The production of fossil fuels significantly decreased by 2000, as well as the level of direct industrial emissions, but both had subsequently recouped to a lesser extend by 2013. Overall, there was a 24% decrease in energy production, measured in physical units from 1,857 million tons of oil equivalent (Mtoe) in 1992 to 1,409 Mtoe in 2000 compared with a 23% drop in release of CO_2 emissions in the allotted period (ROSSTAT, 2003, 2010, 2014, section 13.28). Subsequently the production climbed to 1,880 Mtoe in 2013, which is equivalent to a 34% increase from the level of year 2000, compared with a 26% rise in emissions for the same period. Having less emissions per unit of produced energy resource indicates there may have been an improvement in production technology since the beginning of 2000s. Further, as can be seen in Table 4.5, there was no significant change in the structure of primary energy production in the period of 1992-2013. Oil and gas comprised 40% respectively of the total primary energy production, coal - 13-14%, and sustainable electricity, which is listed under category 'Other' and consists of hydro, nuclear, geothermal and wind sources, comprised the remaining 6-7%. The consistency of the structure in the production of primary energy resources over time indicates that there was no switching between energy resources.



Sources: Russian Statistical Yearbook, IEA.

Figure 4.4: Electricity and heat production by fuel type

Due to the sole dominance of the Electricity sector in direct emissions generation, it is instrumental to understand the structure of electricity production in Russia. Figure 4.4 provides graphical representation of fuel types used for production of electricity in the period of 1992-2013 (IEA, 2018). The quantity of produced electricity fell by 13% by the year 2000, and, thereafter, jumped by 20% by 2013. The associated direct CO_2 emissions fell by 30% between 1992-2000, then rose by 11% by 2013. Overall, there was a 5% increase in electricity generation and a 23% drop in direct emissions release by this sector over the period. To account for a drop in emissions, it is helpful to check the structure of the electricity generation. Gas is the leading resource used in electricity generation, followed by hydro, nuclear and coal sources. The hierarchy remained unchanged throughout the period with slight deviation between the last three resources by 1-2%. Over the period the share of gas increased from 42% to 50%, the oil share decreased from 10% in 1992 to 1% in 2013, the share of nuclear source increased from 12% to 16%, the coal and hydro shares remained unchanged at 15% and 17%, respectively. It would appear the decreased amount of emissions per unit of generated electricity can be attributed to a change in the fuel mix towards less-emission intensive resources (i.e. gas and nuclear) as well as to a potential improvement in production technology. We will check this assumption in the next sections when we complete the structural decomposition.

4.5 Results and discussion

4.5.1 Embodied emissions

So far, we have been discussing direct emissions. However, with the aid of the input-output methodology it is possible to redistribute direct emissions through interindustrial linkages to the sectors responsible for their generation via final demand channels. Mathematically, this redistribution can be achieved through environmental input-output multipliers, $\mathbf{f}'(\mathbf{I}-\mathbf{A})^{-1}$, that we defined in Section 4.3. An environmental multiplier for an industry j estimates how much carbon emissions are generated in the economy while satisfying a unit of final demand for sector j's output.

Figure 4.5 presents such embodied emissions for the previously defined 11 sectoral groups. Figure 4.6 presents embodied emissions by final demand category: household consumption, government consumption, gross capital formation, and foreign demand. And, finally, Figure 4.7 describes the sectoral composition of the embodied emissions in each final demand category.

Generally, it can be observed that emissions get distributed more equally across all sectoral groups when compared to direct emissions where they were predominantly attributed to electricity production. Comparing Figure 4.3 and Figure 4.5, we note a large shift of emissions to industrial production cluster (manufacturing, construction). The Electricity sector now shows more moderate emission responsibility. Among the energy producing sectors, petroleum production had negative embodied emissions in 1992.

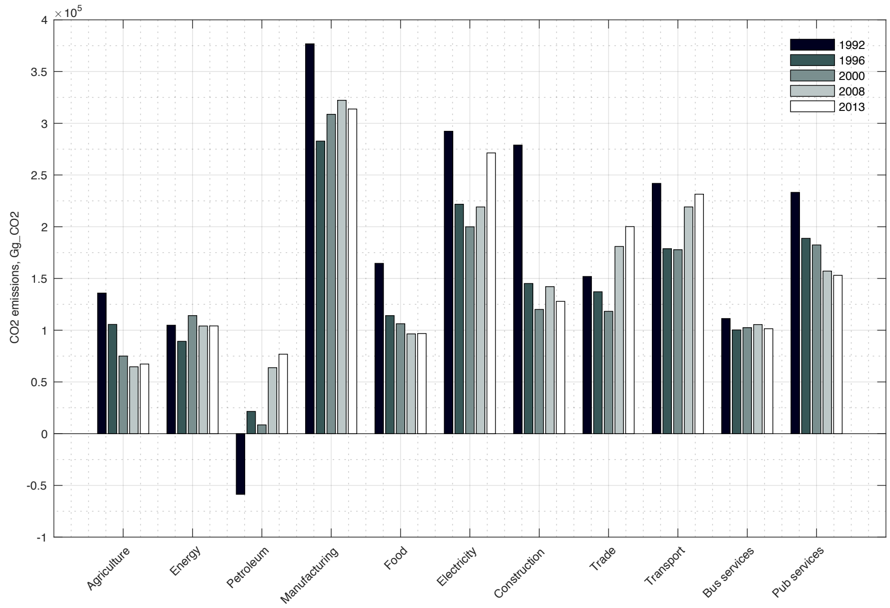


Figure 4.5: Embodied CO_2 emissions by sector cluster

Analytically, embodied emissions for each sector are calculated as $\mathbf{f'L_d y}$. Therefore, if the final demand is negative for some sector j, the results for embodied emissions for that sector will be negative. The negative embodied emissions in the context of input-output methodology signify an amount of emissions foregone in the economy directly and indirectly given an outflow of capital from the oil refining sector. It can be due to an underutilization of existing refining capacity or due to a closure of refineries. Production of raw energy resources exhibits one of the lowest levels of embodied CO_2 emissions when compared to other sectoral clusters.

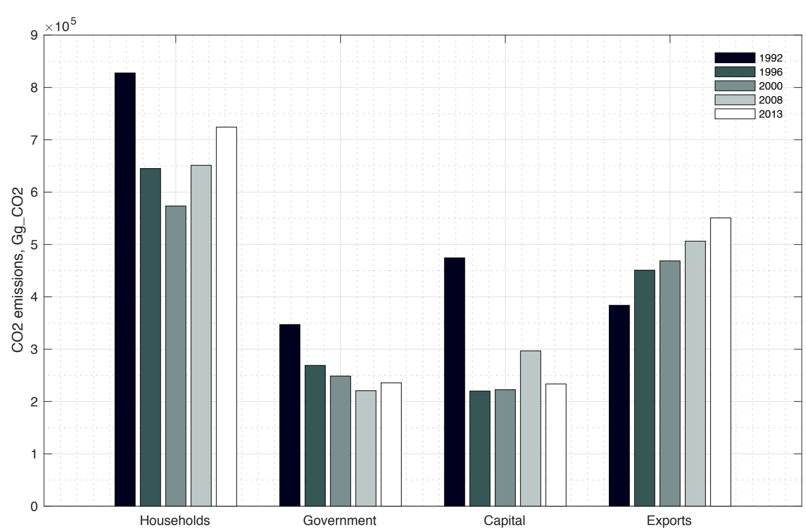


Figure 4.6: Embodied CO_2 emissions by final demand category

According to Figure 4.6, Russia's CO_2 emissions are mostly driven by the household final demand ($\approx$ 40% of the total emissions in each year). The importance of exports is becoming more pronounced with each year, where in 1992 its share in total demand was 19% and in 2013 it is already 32%. The shares of government expenditure and gross capital formation comprise the remainder in approximately equal share (15-17%). The rise of embodied emissions in household demand since the year 2000 indicate an improving economic situation in the country, while growing embodied emissions in foreign trade point at what fuels this growth.

The sectoral composition of the embodied emissions in each final demand category can be observed in Figure 4.7. As can be seen, the emissions embodied in private and foreign final demand are more uniformly disbursed across sectors, whereas, the emissions embodied in government consumption and investment are concentrated in a handful of sectors. The emissions embodied in private consumption are predominantly concentrated in the Electricity, Food, and Manufacturing sectors. However, we can note a certain structural shift in consumer preferences over the studied period, where in the beginning of 1990s the preferences would lie with durable goods with gradual shift starting early 2000s towards consumption of services. Growing importance of market services in consumer spending suggests Russia being on the right development track towards becoming a market economy. The emissions embodied in foreign consumption are clustered in the Energy, Manufacturing, Transport, and Trade sectoral clusters. The emissions embodied in government consumption are mostly concentrated in public services ($\approx$ 60%) and electricity production ($\approx$ 20%). When it comes to capital formation, the majority of embodied emissions are concentrated in construction, manufacturing, and transportation. As we see here, this is the demand group that is responsible for the negative embodied emissions in petroleum production that we observed in Figure 4.5.

The data for Russia's direct and embodied CO_2 emissions by sector cluster and by final demand category are available in Appendix C, Tables C.2.

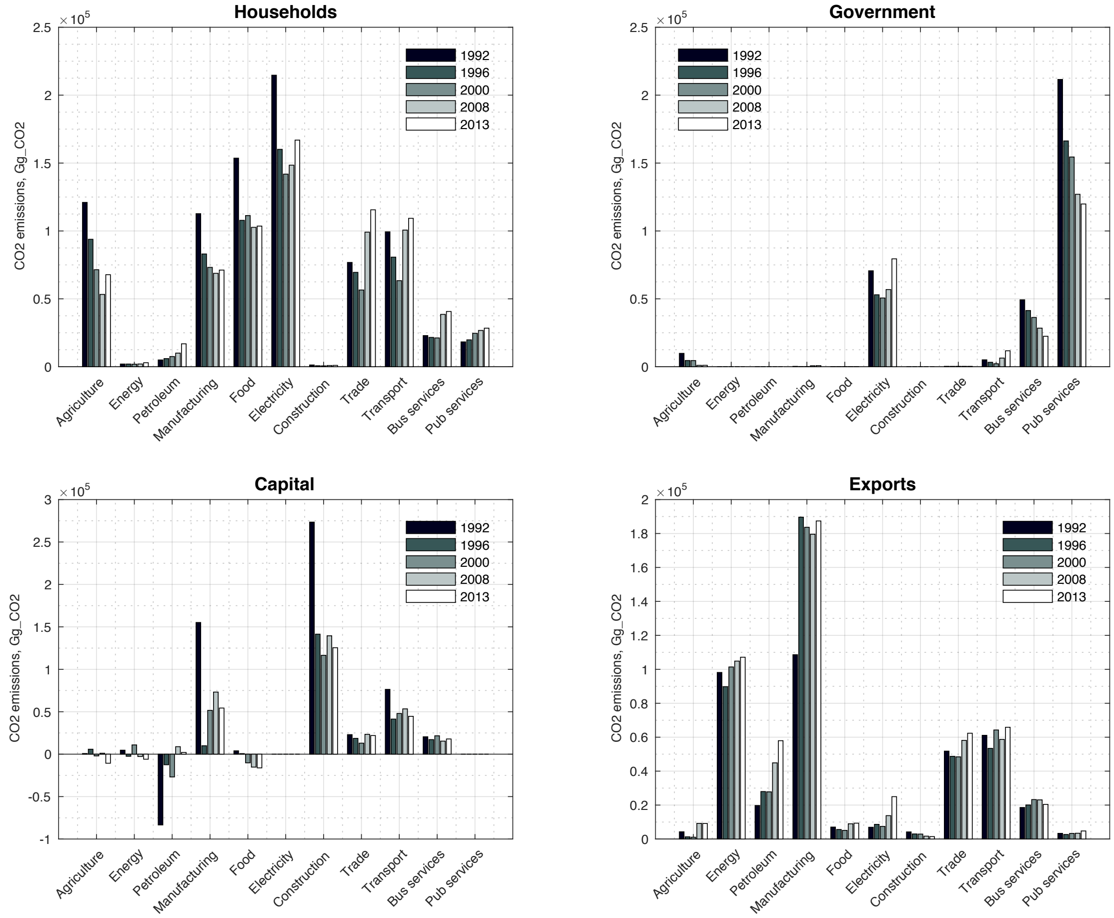


Figure 4.7: Embodied CO_2 emissions by sector cluster and final demand category

4.5.2 Drivers of embodied emission changes

We proceed to derive the driving forces of emission changes over the studied period. Figure 4.8 provides graphical representation of the structural decomposition.

We decompose the emission changes into six driving effects: emission efficiency change, change in fuel mix, energy efficiency change, change in production technology, change in the structure of final demand, and change in overall final demand[9]. For any partitioned time period, we are able to pin down which effect is most responsible for changes in carbon emissions. Due to the ideal decomposition property of the S/S-D&L weight function, the sum across all individual effects for a given time period equals the total embodied emission change for the same period. Due to the consistency in aggregation (i.e. time reversal) property, the sum of an individual effect across all time periods returns the total for that component as if we would perform a decomposition

[9]The results are summarized in Appendix C, Table C.3.

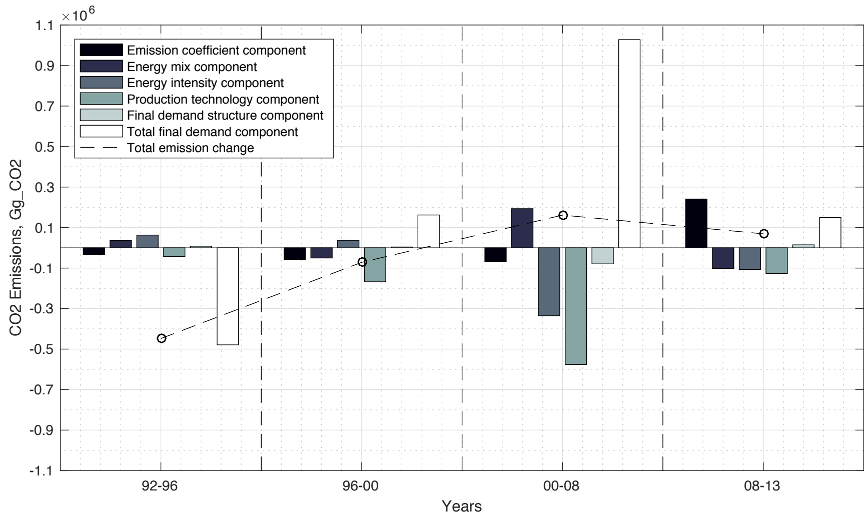


Figure 4.8: Structural decomposition of emission changes

on the polar years of 1992 and 2013, and the sum of all components across four time sub-periods returns an aggregate amount of embodied emission change for 1992-2013.

In the first period of 1992-1996 the total embodied emissions decreased by 447,911 Gg-CO2, which is the same amount as the change in total industry emissions in Table 4.4. As can be seen in Figure 4.8, the main driver of the decrease is the total final demand effect (ΔC_{ytot}), which contributed 479,039 Gg-CO2 to the emissions reduction. Figure 4.9 provides an additional dimension to the structural decomposition, separating effects by final demand category. We can observe that all domestic final demand groups contributed to the decline of emissions. In the beginning of 1990s Russia encountered fundamental changes inflicted by the political regime change. The dynamic restructuring of the economy accompanied by rapidly changing economic and foreign policy had caused significant uncertainty in the capital markets, which led to an outflow of investment. Our estimates show that these changes caused a drop in emissions of 263,061 Gg-CO2 mostly due to an outflow of capital from such industries as construction, production of machinery and equipment, and R&D. During the transition many companies had straggled to pay their employees which led to labor strikes and further disruptions to already limping domestic supply chains. The crosscut of household expenditure during this period indicates that the households had their consumption reduced for products and services of the food, transportation, textile, electricity, and trade industries, which led to an additional 131,481 Gg-CO2 decline in emissions. The government reduced its expenditure on public administration and defense contributing an additional 92,738 Gg-CO2 to emissions decline. The remaining structural decomposition effects are of a minimal size. Despite many economic hardships during this period, the production structure of the Russian economy starts exhibiting signs of growing efficiency confirmed by a negative production technology decomposition component (ΔC_{lstr}, Figure 4.8). The main contributing factors to emissions increase in this period are energy intensity of production (ΔC_{gint}) and carbon-reach energy mix (ΔC_{emix}). Perhaps the effect of these two components would have been higher if the output production would not have declined by 31% during this period (based on internal calculations). As can be seen in Figure 4.8, the overall contribution of these two effects is small comparative to the main effect. The production remains energy intensive with energy mix largely of carbon origin. As previously noted in Section 4.4, there was little to no switching between types of energy resources.

During the period of 1996-2000 the emissions released by the economy continue to decline, though at a much slower rate than in the previous period. The total change in emissions in this period is -71,700 Gg-CO2. Overall, as can be seen in both Figure 4.8 and Figure 4.9, all six structural effects are of modest size compared to those in the period of 1992-1996. It suggests that main restructuring of the economy has been concluded by this period. But, many economic changes were still underway which included privatization of the state property and further establishment of business sector as well as further financial reforms. In spite of the overall improving economic climate, there was a lack of debt control by the state which combined with fixed exchange rate left the financial system vulnerable to speculative shocks. It led to the 1998 financial crisis. The recovery from the crisis was quick with only rudiments surviving to the year 2000 (World Bank, 2003). The currency default and growing international energy prices enabled economic recovery with an increase in Russia's exports. Much of the emissions increase during this period, as seen in Figure 4.9, can be attributed to the foreign demand sector (ΔC_{ytot}). During the period of 1996-2000 the output production rose by 9% (internal calculations). The drivers of the emissions decrease are the improved production and environmental technology (ΔC_{lstr} and ΔC_{ecof}) and change in fuel mix in the production structure (ΔC_{emix}). The biggest improvement in production technology occurred in electricity generation as well as in energy production. An improved emission coefficient component is an indicator of switching to cleaner fuel sources in power generation. According to Figure 4.4 and Table 4.5, there was a switch from oil to gas and nuclear power. The energy intensity component (ΔC_{gint}) still is a contributing factor to emissions, which points at a relative energy inefficiency of production.

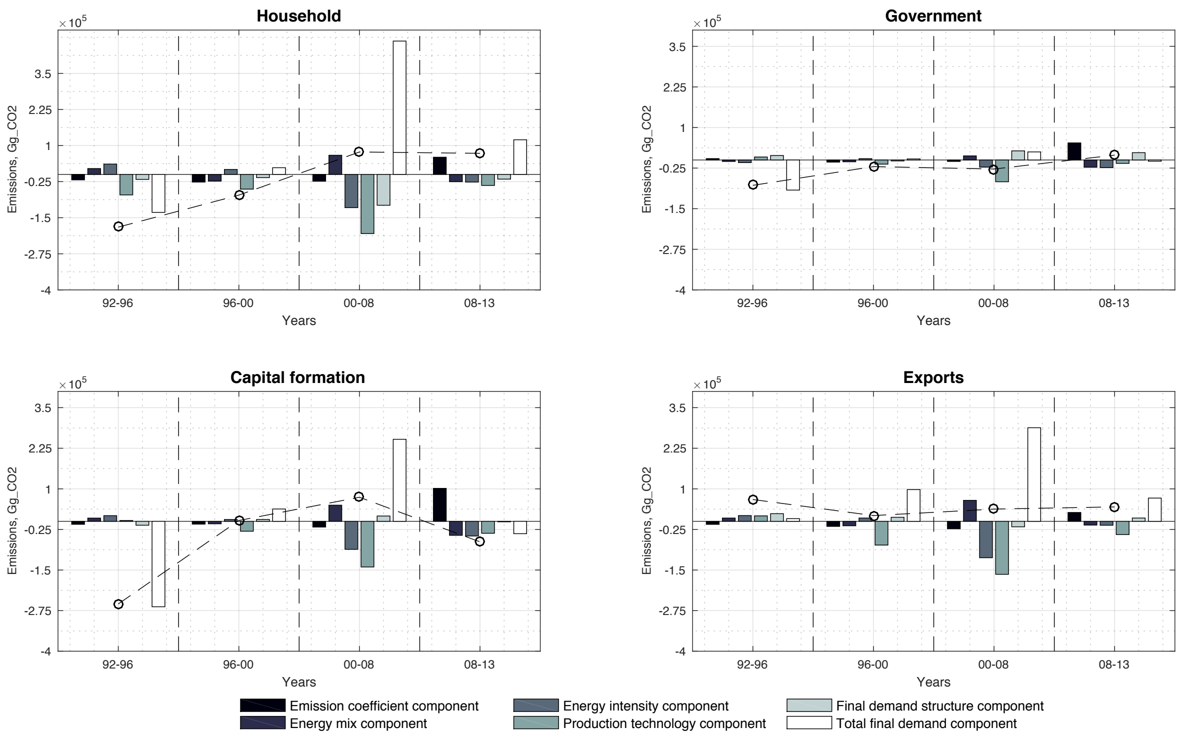


Figure 4.9: Structural decomposition analysis of emission changes by final demand group

The third studied period of 2000-2008 is the period of rising economic prosperity. The economy has grown by 66% (Table 4.4). The federal budget was running a surplus for eight straight years (Russian Federal Treasury, 2018). The share of revenue from sales of oil and gas in the federal budget rose to 47%. The rising prices for oil and gas, realization of productive capacity of capital and labor that was dormant along the entire 1990s, growth of real wages, and structural change of production all fueled economic growth and spurred consumption. The total final demand component (ΔC_{tot}) is the major driver of the emissions in this period. It caused emissions to increase by 1,027,569 Gg-CO2 in this period, 45% of which were generated through household demand, 28% by exports, 25% by capital, and only 2% by government expenditure

(Figure 4.9). To put this number into perspective, this effect is larger than total carbon emissions recorded for almost any country in the world except for China, the USA, India, and Japan (EDGAR, 2017). Nearly 90% of this effect was, however, counteracted by improvements made in (Leontief) production structure (ΔC_{lstr}) by 575,855 Gg-CO2 and by energy efficiency improvements (ΔC_{gint}) by 335,555 Gg-CO2 (Appendix C, Table C.3). While discussing energy and electricity generation in Russia in Section 4.4, we underlined a potential efficiency improvement occurring since the beginning of the 2000s. Now in Figures 4.8 and 4.9 we see an empirical support to this conclusion. The energy mix (ΔC_{emix}) still remains highly fossil fuel based. The final demand structure (ΔC_{ystr}) has also evolved in this period away from manufacturing to business services causing an additional 79,311 Gg-CO2 in reduced emissions. Overall, the CO_2 emissions increased by 161,530 Gg-CO2 in this period.

During the last period of 2008-2013 the trend of rising emissions continues. The total embodied CO_2 emissions increase by 69,117 Gg-CO2. The size of the individual effects is more modest relative to the previous time period. After a decade of economic growth, Russia experienced a deceleration in the wake of the Great Recession. Having failed to diversify its revenue sources and still being highly dependent on carbon prices, the economy slid into recession along with the rest of the world. But in contrast to many other countries, Russian slowdown lasted significantly shorter and in 2009 the economy already exhibited signs of recovery. The quick rebound was partially due to having built the world's largest international reserves, partially due to low sovereign external debt, and partially due to recovering oil price (World Bank, 2008). Overall, over the period of 2008-2013 the economy grew only by 7%. The main driver of emissions increase in this period is, for the first time in the entire study, the emission coefficient component (ΔC_{ecof}) that caused carbon emissions to increase by 240,926 Gg-CO2 (Appendix C, Table C.3). The emission coefficient effect is defined as a measure of CO_2 emissions released per unit of consumed fuel type in the production process and is an indicator of the state of environmental technology/emission efficiency. Table 4.5 and Figure 4.4 support no switching in fuel type in production process and in power generation during this period. If there would have been a switch (towards more carbon-intensive fuel type), we could argue that this switch was the reason for the increase in emissions.

But, since there was no switch in fuel in production process, it leads to a conclusion that, for the first time since the beginning of the study, the environmental production technology shows signs of deterioration. The second contributing driver, though more modest than in the previous period, is the total final demand effect (ΔC_{ytot}) that leads to an additional increase in CO_2 emissions by 149,602 Gg-CO2. According to Figure 4.9, most of the emissions are driven by the domestic private and foreign final demands. There is an outflow of investment in this period. The two effects were counteracted by the continuing improvement in production technology and rising energy efficiency.

In summary, the objective of this study was to identify the main drivers of the CO_2 emission changes of the Russian economy during the period 1992-2013. The results suggest that the economy remains highly dependent on flowing revenues from sale of fossil fuels. This leaves the country being vulnerable to highly correlated shocks of a decline in oil price, an interruption in capital flows, and a decline in the market sentiment (World Bank, 2008). Our study shows each time there is a shock the economy exhibits a significant response in emission generation through final demand channel. All throughout the 22 years period there have been made significant efforts to restructure the economy with the purpose to position it on the path of medium- and long-term sustained growth. We note this through the emission reduction due to improvements in production technology and energy efficiency. However, these improvements were not enough to counteract the emissions embodied in total final demand channel. The improvements in the production structure were mainly due to a shift towards less energy-intensive industries (i.e., market services) and increased industrial capacity utilization. Despite growing production efficiency, the environmental efficiency has been declining since the year 2008. In order to meet the environmental pledge along with achieving the long-term sustained growth Russian policy makers need to intensify the efforts of the economy's diversification and modernization, work towards decreasing the budgetary and the production reliance on fossil fuels, strengthen institutions as well as the financial sector.

4.6 Conclusion

Russia is one of the chief producers of energy resources in the world and, therefore, also plays a leading role in generation of energy-related CO_2 emissions (IEA, 2014). The aim of this study is to analyze the drivers of energy-related CO_2 emission changes generated by the Russian economy in the period of 1992-2013. To our knowledge, Russian emission changes have been studied only in the multi-region setting[10], but not in the single-region setting. We adopt an environmentally extended input-output methodology to initiate a general discussion of the embodied energy-related CO_2 emissions generated by the Russian economy and the structural decomposition analysis technique to study the drivers of emission changes. In this study we use input-output data released by the Russian Academy of Sciences and harmonized energy use and emission data developed by the Eora database. We divide the time period of 1992-2013 into 4 sub-periods (1992-1996, 1996-2000, 2000-2008, and 2008-2013).

The results suggest that the Russian economy remains receptive to shocks, particularly demand shocks. There is a significant response in emission generation through the final demand channel each time there is an economic or a political change domestically or internationally. Nearly the entire emission change in 1992-1996 was triggered by the weak demand brought on by weak macroeconomic performance and low market sentiment. Once economic conditions improved in the late 1990s - early 2000s the continuously growing demand led to a steady rise in carbon emissions adding an additional 1,027,569 Gg-CO2 in total final demand effect during 2000-2008. This effect is so significant that only the total emissions of the top polluting countries such as China, the USA, India, and Japan exceed it (EDGAR, 2017). Perhaps this trend of steadily rising emissions triggered by growing demand would have continued if the Great Recession would not have started in 2008. Such susceptibility to demand shocks can be partially explained by approximately 50% of the federal budget being financed through revenues brought by the sale of oil and gas (Russian Federal Treasury, 2018). It appears whenever there is a shock to energy prices the economy exhibits a decline in emissions, and vice versa, once the fossil fuel prices recover the emissions start to climb being infused by added expenditure levels.

[10] Sun (1998); Xu and Dietzenbacher (2014); Lan et al. (2016); Wang et al. (2017a).

Additionally, our results show that as of the end of 2013 the economy still predominantly specialized in energy-intensive production. Being reliant on energy sales and having an energy-intensive specialization of production suggests that the Russian economy is going to continue the positive trend of emission generation. Vast areas of Russia have highly continental climate, for which it may prove difficult to reduce domestic energy consumption and, therefore, domestic sales, which account for approximately 60% of total energy sales. Also, having a natural abundance of fossil fuel resources further disincentivizes the government to switch to non-fossil fuel resources in the production process. Russia would benefit from diversification of production. If the change is made to reduce the budgetary reliance on the revenues from energy sales, the production would become less energy and emission intensive. Further improvement in emission avoidance could be achieved through 'decarbonization' of electricity and heat generation, starting with further reducing the coal content in the fuel mix (Figure 4.4).

In the structural decomposition analysis, we note that the production technology in Russia exhibits significant improvement starting in the early 2000s. However, during the period of 2008-2013 the environmental technology shows signs of deterioration for the first time since 1992. Even though as of 2013 Russia meets its 2020 climate pledge made to UNFCCC of reducing emissions by 20% or more relative to the year of 1990, the trend of emissions in the past decade was positive. It can be argued that the drop in emissions, that predominantly occurred during the 1990s, could be attributed to political and economic hardships that weakened final demand, investment, and, as a consequence, production. And, that since the political scene became more stable and the economy recovered since the early 2000s, there was not enough conscious action to mitigate rising emissions.

The structural decomposition demonstrates a continuous improvement in production technology over the past 20 years with picking up energy efficiency in the early 2000s. However, the environmental aspect of the production technology becomes less efficient in the last period. This again brings to the conclusion of needed diversification of production shifting away from energy-intensive industries and diversification of budgetary revenue sources. Additionally, Russia would benefit from investment into modernization of the environmental technology of production. Lastly, further decarbonization of electricity and heat generation is required. That means, further reduction of coal content followed by a reduction of gas content and subsequent increase of existing and new sources of sustainable energy. As of July 2018, Russia is the only BRIICS country that is not a beneficiary of the Green Climate Fund, which is designed to help developing countries incorporate means to mitigate emissions (Roman et al., 2017). As the Russian energy is highly demanded by the main contributors to the Green Climate Fund, it seems reasonable to include Russia in the list of the beneficiaries. It will help fund the necessary modernization.

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Chapter 5

Conclusion

The main aim of this thesis is to complete a thorough analysis of how the production structure of the Russian economy evolved and what were the effects of the structural change on emissions generation throughout one of the most fundamental times in Russian history of 1980-2013. As the oldest and the largest economy in transition, Russia has been striking research interest for many years[1]. Being deprived of market influences, by the end of the Soviet era in 1991 the Russian economy was characterized by a disproportionally large industrial sector which comprised of oversized plants and employed the majority of the labor force. The non-market services sector was underdeveloped. Because of the forced low labor productivity due to labor immobility, unrealized production capacity potential, vast amounts of human capital and natural resources, at the start of the transition there was an expectation that given the right structural changes the economy will step on the right development path and become a developed, market economy.

Russia is one of the main global fossil fuel producers accounting for 12.2% of the global oil production and for 17.3% of the global gas output (BP, 2018). It positions Russia in 2015 on the fourth place in the world by total released greenhouse gas emissions generating 5% of the world's total (EDGAR, 2017). Being such an important player on the world energy market and having a complex, energy-intensive production structure with untapped potential for productivity and efficiency gains makes Russia an interesting case study. This thesis attempts to disentangle the driving forces behind

[1] Leontief (1936); Doehrn and Heilemann (1996); Raiser Schaffer and Schuchhardt (2004); World Bank (2003a,b, 2008); Alexeev and Weber (2013).

the emission changes over the period 1992-2013 and assesses the progress of the Russian economy towards sustainability.

An analysis of structural changes in the economy assumes that the interdependent components of the economic system comprise a complex unit and include a system of peculiarities that do not allow for their study by analyzing individual components (Jackson, 2003). In this thesis we choose an input-output modeling framework, whose main characteristic is to be able to disentangle the sectoral interdependencies while preserving the holistic view of the economy, as a central methodological framework when studying the structural composition of the Russian economy. With input-output framework, it is possible to identify the bottlenecks in the production structure of the economy removing which could initiate productivity gains and economic growth.

The second chapter of this thesis is dedicated to conducting a comprehensive sensitivity analysis of the available Russian input-output data. One of many inherited issues from the Soviet period was the material national accounting system that was not compliant with the system of national accounts used by market economies. The conversion process to the new statistical system took over 20 years where even in the 2010s some rudiments of the socialist accounting survived. Such co-existence of the two systems combined with known institutional problems create a degree of prudence over the quality of Russian data. There is a significant body of literature dedicated to studying the uncertainty in the input-output data (ten Raa, 2017). To test the quality of the Russian input-output data, assess the degree of uncertainty propagation in derived input-output multipliers we use the Monte Carlo simulation approach (Roland-Holst, 1989; Dietzenbacher, 2006). We find that derived from the Russian input-output data multipliers are able to withstand random perturbances in the raw data to the same degree as the multipliers based on the data from developed countries (e.g., Germany, the Netherlands). The multipliers are on average more stable than the underlying perturbed data. The results hold across various robustness specifications. We add to the existing literature on uncertainty treatment by showing that the results obtained in Dietzenbacher (2006) were not dependent on the country choice and despite many institutional, political, and socio-economic differences also extend to Russia.

The third chapter provides an overview of economic and social aspects of Russian development over the period of 1980-2006. We provide a detailed study of the evolution of the production structure of the Russian economy based on the analysis of the inter-industrial linkages. The input-output framework allows in analytically simple way to measure the economic impact of individual industries on the entire economy. To accomplish this objective we derive a variety of input-output multipliers. Via the notion of input-output multipliers we analytically disentangle the effects of the exogenous demand change in one industry on the entire economy.

By analyzing the strength of the interindustrial linkages while controlling for the sectoral size, we find that during the 1980s the most important sector in terms of its ability to stimulate additional output and value added in all other sectors was the broad manufacturing sector (especially machine-building sector). Hence, the Russian economy as other socialist economies was characterized by heavy industrial production. During the Soviet episode of our time series, the industry employed the largest share of labor force - over 40%, approximately 15% were occupied in agriculture, and the rest were divided between market and non-market service sectors. In the beginning of the 1980s the labor productivity across the economy was relatively flat supporting the fact that there was no differential productivity growth or sectoral reallocation of labor during that period. The economic situation started to evolve during Perestroika (1985-1991). During Perestroika a series of economic reforms have been introduced with the intention of establishing an openness to international trade, authorizing foreign investment joint ventures, legalizing private labor, and authorizing an establishment of independent cooperatives (Vause, 1989). This period marks a shift in specialization of the economy towards extraction of primary resources and provision of services as shown by net multipliers, accounting multipliers, and GDP multipliers. Starting at the end of 1980s a strong positive correlation between the price for fossil fuels and the gross value added emerges. The output accounting multiplier results show that when accounting for the size of the final demand not only there is a shift away from heavy industrial production, but that the Russian exports predominantly consist of primary resources (oil, gas, ferrous and non-ferrous metals). According to official statistics, approximately 80% of exports were natural resources, where a half of them was from the oil and gas sectors. The imports were largely comprised of products of machinery, textile, and food industries. By 2006 the production structure of the Russian economy (characterized by the strength of the backward linkages) remained energy-intensive, however, there was a clear shift from specialization in manufacturing in the early years towards specialization in resource-extracting sectors such as production of oil and (ferrous and non-ferrous) metals in the latter years. Starting late 1990s the strength of the backward linkages of such tertiary sectors as 'Trade', 'Research and development', 'Financial services', and 'Communal and (market) consumer services' grows significantly in size relative to other sectors of the economy. These sectors also exhibit growing labor productivity.

While calculating employment multipliers we identified sectors within the Russian economy that are most responsive to added final demand when creating extra full-time employment. We noted that the majority of extra employment would be created through direct effect - directly in the sector that receives an injection of extra expenditure. Therefore, if the Russian government would find itself in the situation with high general unemployment, expenditure into these sectors would be the quickest way to create new positions. In fact, this is exactly what the Russian government did during turbulent 1990s - early 2000s stimulating employment in non-market service sectors. However, instead of investing into the development of human capital (positions in education, medicine), the government created low-level, low-productivity jobs (janitors, cleaners). It led to over-saturation by people occupied in non-market services (over 30% of total labor force in 2000s) when compared to market economies with comparable income (Raiser Schaffer and Schuchhardt, 2004). The policy recommendation, given the objective of evolving into a developed, market economy, is to stimulate reallocation of labor into high productivity sectors.

The fourth chapter is dedicated to studying the direct and embodied energy-related CO_2 emissions and their drivers released by the Russian economy in the period of 1992-2013. To accomplish this objective, we utilize an environmentally extended input-output methodology and the structural decomposition analysis technique. In the structural decomposition analysis, we separate the change in embodied CO_2 emissions into six associated components based on an input-output model: emission efficiency change, change in fuel mix, energy efficiency change, change in production technology, change in the structure of final demand, and change in overall final demand. We find that the Russian economy is significantly responsive to demand shocks. Nearly the entire emission change in 1992-1996 was triggered by weak demand brought on by slaggish macroeconomic performance and low market sentiment. Once economic conditions improved the growing demand led to a steady rise in carbon emissions in the 2000s. Additionally, starting early 2000s the production technology starts to exhibit significant improvement. However, during the period of 2008-2013 the environmental component of the production technology starts to show signs of quick deterioration for the first time since 1992. As of the end of 2013 the economy still predominantly specialized in energy-intensive production. Even though as of 2013 Russia meets its 2020 climate pledge made to UNFCCC of reducing emissions by 20% or more relative to the year of 1990, the trend of emissions in the past decade was positive. It can be argued that the drop in emissions, that predominantly occurred during the 1990s, could be attributed to political and economic hardships that weakened final demand, investment, and, as a consequence, production. And, as economic conditions recovered the emissions were on the rise and there was not enough policy action to mitigate rising emissions. In order to combat the positive trend in emissions generation the government needs to reduce the budgetary reliance on revenue sources from sales of gas and oil, modernize the environmental technology of production, and concentrate on diversification of production reducing the importance of energy-intensive industries. Also, further decarbonization of electricity and heat generation is required.

This thesis can be extended in a number of ways. One such way is to introduce new hypothetical industries into existing input-output model to assess the direct, indirect, and induced effects of the newly created industries through backward linkages on the economy. For example, at present the Russian national accounts do not explicitly identify renewable energy sectors. By introducing a new renewable sector, i.e. wind, solar, into the existing model, one could estimate an impact of investment into such a sector on, for example, job creation. Miller and Blair (2009, p. 633) describe two analytical approaches on how a new industry can be modeled. Malik et al. (2014) and Garrett-Peltier (2011, 2017) provide a detailed coverage with application to energy industry. This extended input-output model with new hypothetical energy industries can be used to create a computable general equilibrium (CGE) model for Russia. Another interesting extension to the environmentally extended input-output model presented in this thesis would be to assess the impact of pollution on health quality. Given Russia's heavy specialization in extraction of primary resources, certain parts of the country are known to be among the most environmentally polluted areas in the world. People residing in these locations are prone to develop autoimmune diseases (e.g., asthma, multiple sclerosis, rheumatoid arthritis). An example of such application can be found in Vargas and Dietzenbacher (2012) who studied deaths attributable to pollution and payments made to the health industry by economic activities.

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Appendix A. Supplementary Material for Chapter 2

Code	OKONh	Industry
1	10000	Electric and heat-generating energy
2	11210	Products of oil excavation
3	11220	Production of oil processing
4	11230	Products of gas production
5	11300	Coal
6	11410, 11610	Oil shales and peat
7	12100	Ferrous metals
8	12200	Non-ferrous metals
9	13000	Products of chemical and petrochemical industry
10	14000	Machinery and equipment, metal products
11	15000	Forestry, wood, pulp and paper equipment
12	16100	Building materials (including products of glass and porcelain industry)
13	17000	Products of light industry
14	18000	Products of food industry
15	19000	Other manufactured goods
16	60000	Construction
17	20000, 21000, 22000, 29000, 30000, 31000, 32000	Agricultural products, maintenance and servicing of agricultural industry; forestry products
18	51000	Transportation services
19	52000	Communication services
20	70000	Trade services (including catering)
21	87000	Other non-manufacturing services
22	80000, 90000	Housing and communal services
23	91000, 92000, 93000, 95000	Health services, physical culture and social services, education, culture and art
24	85000	Scientific services, geology and excavation of resources, geodetic and meteorological services
25	96000, 97000, 98000	Financial intermediation, insurance, governance and public services

* In ROSSTAT IOTs codes 2-4 (11210+11220+11230) are combined into a single sector ”Oil and Gas Production” and codes 18-19 (51000+52000) into a single sector ”Transportation and Communication Services”. The IEF IOTs preserve the detail of all 25 codes.

Table A.1: The OKONh industry classification

Code	OKVED/NACE	Industry
1	AtB	Agriculture, Hunting, Forestry and Fishing
2	11	Crude Oil
3	11	Natural Gas
4	10	Coal
5	12	Other Fossil Fuel, Peat and Nuclear Materials
6	CB	Mining of Metal Ores and Fossils, Except Fuel
7	15t16	Food, Beverages and Tobacco
8	DB-DC	Textiles and Textile Products
9	20	Wood and Products of Wood and Cork
10	21t22	Pulp, Paper, Paper, Printing and Publishing
11	23	Coke, Refined Petroleum and Nuclear Fuel
12	24exc24.1	Chemical Production
13	24.1	Pharmaceutical Production
14	25	Rubber and Plastics
15	26	Other Non-Metallic Minerals
16	27	Basic Metals
17	28.1-28.6	Fabricated Metals
18	28.7	Other Metals, Except for Machinery
19	29	Machinery, Nec.
20	30	Office and computer equipment
21	31	Electric Equipment
22	32	Communication Equipment
23	33	Optical, Precision, Medical Equipment
24	34	Motor Vehicle Equipment
25	35.1	Water Equipment
26	35.3	Aircraft Equipment
27	35.2, 35.4-35.5	Rail and Other Equipment
28	36t37	Manufacturing, Nec; Recycling
29	E	Electricity, Gas and Water Supply
30	F	Construction
31	G	Wholesale and Retail; Repair and Servicing
32	H	Hotels and Restaurants
33	I	Transportation and Supporting Activities
34	64	Post and Telecommunications
35	J	Financial Intermediation
36	70	Real Estate Activities
37	71	Renting of Machinery and Equipment
38	72	Computer and Related Services
39	73	R&D
40	74	Other Business Services
41	L	Public Administration and Defense; Compulsory Social Security
42	M	Education
43	N	Health and Social Work
44	O	Other Community, Social and Personal Services

* Under the IEF nuclear fuel production is a part of 'Mining of metal ores and fossils, except fuel' sector and not 'Coke, Refined Petroleum and Nuclear Fuel'.

* The WIOD IOTs have sectoral detail 34.

* The Eora IOTs have sectoral detail 47.

The Eora IOTs resemble the IEF IOTs with exception that the production of fossil fuels is aggregated and the sector 29 (E) 'Electricity, Gas and Water Supply' and the sector 33 (I) 'Transportation and Supporting Activities' is disaggregated. Details are in the main text.

Table A.2: The OKVED/NACE Rev. 1 industry classification

Number	OKVED/NACE Industry	Code	OKONh Industry	Code
1	Agriculture, hunting, forestry and fishing	AtB	Agriculture	20000
2	Crude oil	11	Fuel industry	11200
3	Natural gas	11	Natural gas industry	11230
4	Coal	10	Coal industry	11300
5	Other Fossil Fuel, Peat and Nuclear Materials	12	Shale and peat industry	11410-11610
6	Mining of Metal Ores and Fossils, Except Fuel	CB	Ferrous metallurgy	12100
7	Food, beverages and tobacco	15t16	Food industry	18000
8	Textiles and textile products	DB-DC	Light industry	17000
9	Wood and products of wood and cork	20	Logging, woodworking and pulp-and-paper industry	15000
10	Pulp, paper, paper, printing and publishing	21t22	Logging, woodworking and pulp-and-paper industry	15000
11	Coke, refined petroleum and nuclear fuel	23	Fuel industry	11200
12	Chemical production	24exc24.1	Chemical and petrochemical industry	13000
13	Pharmaceutical production	24.1		19310
14	Rubber and plastics	25	Chemical and petrochemical industry	13000
				19310
15	Other non-metallic minerals	26	Machine-building and metal working	14000
			Medical equipment industry	19320
16	Basic metals	27	Machine-building and metal working	14000
			Medical equipment industry	19320
			Ferrous metallurgy	12100
17	Fabricated metals	28.1-28.6	Non-ferrous metallurgy	12200
18	Other Metals, Except for Machinery	28.7	Machine-building and metal working	14000
19	Machinery, nec.	29	Machine-building and metal working	14000
20	Office and computer equipment	30	Machine-building and metal working	14000
21	Electrical and optical equipment	31	Machine-building and metal working	14000
22	Communication Equipment	32	Machine-building and metal working	14000
23	Optical, Precision, Medical Equipment	33	Machine-building and metal working	14000
			Medical equipment industry	19320
24	Transport equipment	34	Machine-building and metal working	14000
25	Water Equipment	35.1	Machine-building and metal working	14000
26	Aircraft Equipment	35.3	Machine-building and metal working	14000
27	Rail and Other Equipment	35.2, 35.4-35.5	Machine-building and metal working	14000
28	Manufacturing, Nec; Recycling	36t37	Machine-building and metal working	14000
29	Electricity, gas and water supply	E	Electric power industry	11100
30	Construction	F	Construction	60000
31	Wholesale and Retail; Repair and Servicing	G	Trade	70000
			Wholesale trade	71100
			Retail trade	71200
32	Hotels and restaurants	H	Catering	71300
33	Transportation and Supporting Activities	I	Transport	51000
34	Post and telecommunications	64	Communications	52000
35	Financial intermediation	J	Finances, credit, insurance, pension security	96000
36	Real estate activities	70	Trade	70000
			Real estate operations	83000
37	Renting of M&Eq	71	Trade	70000
38	Computer and Related Services	72	IT services	82000
39	R&D	73	Science and related services	95000
40	Other Business Services	74	Publishing	87100
			Private security	87400
			Other business activities	84000
41	Public administration and defense; Compulsory social security	L	Administration	97000
			Public amalgamations	98000
42	Education	M	Education	92000
43	Health and social work	N	Health care, physical culture and social security	91000
44	Other community, social and personal services	O	Culture and art	93000

Table A.3: The concordance of the OKVED/NACE Rev. 1 and the OKONh classifications

Year	Sample size	ROSSTAT w/ Kronecker delta	ROSSTAT w/o Kronecker delta	IEF OKONh w/ Kronecker delta	IEF OKONh w/o Kronecker delta	IEF OKVED w/ Kronecker delta	IEF OKVED w/o Kronecker delta	Rus WIOD w/ Kronecker delta	Rus WIOD w/o Kronecker delta	Rus Eora w/ Kronecker delta	Rus Eora w/o Kronecker delta	Ger Destatis w/ Kronecker delta	Ger Destatis w/o Kronecker delta	Ger WIOD w/ Kronecker delta	Ger WIOD w/o Kronecker delta
1998	10	0.084	0.080	0.094	0.091	0.100	0.098	0.091	0.088	0.120	0.117	0.101	0.100	0.100	0.097
	20	0.088	0.084	0.097	0.093	0.098	0.095	0.093	0.090	0.118	0.116	0.107	0.105	0.100	0.097
	50	0.092	0.088	0.097	0.093	0.101	0.098	0.094	0.091	0.118	0.115	0.108	0.107	0.102	0.099
	100	0.093	0.089	0.097	0.093	0.103	0.100	0.096	0.093	0.118	0.116	0.108	0.106	0.103	0.100
	1000	0.096	0.092	0.098	0.094	0.101	0.099	0.096	0.093	0.119	0.116	0.108	0.106	0.103	0.100
	10000	0.096	0.092	0.097	0.094	0.101	0.099	0.096	0.093	0.119	0.116	0.108	0.106	0.103	0.100
1999	10	0.086	0.082	0.095	0.091	0.100	0.097	0.093	0.090	0.119	0.116	0.102	0.100	0.100	0.097
	20	0.088	0.084	0.098	0.094	0.097	0.095	0.094	0.091	0.118	0.115	0.107	0.106	0.100	0.097
	50	0.093	0.089	0.097	0.093	0.100	0.098	0.095	0.092	0.118	0.115	0.108	0.107	0.102	0.099
	100	0.094	0.090	0.096	0.093	0.101	0.099	0.097	0.094	0.118	0.115	0.108	0.106	0.103	0.100
	1000	0.096	0.092	0.098	0.094	0.099	0.097	0.097	0.095	0.118	0.116	0.108	0.107	0.103	0.100
	10000	0.097	0.092	0.098	0.094	0.100	0.097	0.097	0.094	0.118	0.116	0.108	0.106	0.103	0.100
2000	10	0.086	0.082	0.094	0.091	0.100	0.098	0.092	0.089	0.120	0.118	0.101	0.100	0.098	0.095
	20	0.088	0.084	0.097	0.094	0.098	0.095	0.093	0.091	0.119	0.116	0.106	0.105	0.098	0.095
	50	0.093	0.089	0.097	0.093	0.100	0.098	0.094	0.091	0.119	0.116	0.108	0.106	0.100	0.097
	100	0.095	0.090	0.096	0.093	0.101	0.099	0.096	0.093	0.119	0.117	0.107	0.106	0.102	0.098
	1000	0.097	0.093	0.098	0.094	0.100	0.098	0.096	0.094	0.119	0.117	0.107	0.106	0.102	0.099
	10000	0.097	0.093	0.097	0.094	0.100	0.098	0.096	0.094	0.119	0.117	0.107	0.105	0.102	0.099
2001	10	0.083	0.080	0.091	0.088	0.100	0.097	0.089	0.086	0.119	0.117	0.101	0.100	0.098	0.095
	20	0.086	0.082	0.095	0.091	0.098	0.095	0.091	0.088	0.118	0.115	0.107	0.105	0.098	0.095
	50	0.091	0.087	0.094	0.091	0.100	0.098	0.092	0.089	0.118	0.115	0.108	0.106	0.100	0.097
	100	0.092	0.088	0.094	0.090	0.101	0.099	0.094	0.091	0.118	0.115	0.107	0.106	0.102	0.099
	1000	0.095	0.091	0.095	0.092	0.100	0.097	0.094	0.091	0.118	0.116	0.107	0.106	0.102	0.099
	10000	0.095	0.091	0.095	0.091	0.100	0.098	0.094	0.091	0.118	0.116	0.107	0.105	0.102	0.099
2002	10	0.084	0.080	0.093	0.089	0.099	0.097	0.089	0.086	0.120	0.117	0.102	0.100	0.098	0.095
	20	0.086	0.082	0.095	0.092	0.097	0.095	0.091	0.088	0.118	0.116	0.107	0.106	0.099	0.096
	50	0.091	0.087	0.094	0.091	0.100	0.098	0.092	0.089	0.118	0.115	0.108	0.107	0.101	0.098
	100	0.092	0.088	0.094	0.090	0.101	0.099	0.093	0.090	0.118	0.116	0.108	0.106	0.102	0.099
	1000	0.095	0.091	0.095	0.092	0.100	0.097	0.094	0.091	0.119	0.116	0.108	0.106	0.103	0.100
	10000	0.095	0.091	0.095	0.091	0.100	0.097	0.094	0.091	0.119	0.116	0.108	0.106	0.103	0.100
2003	10	0.083	0.079	0.093	0.090	0.099	0.097	0.089	0.086	0.119	0.117	0.103	0.101	0.098	0.095
	20	0.085	0.081	0.094	0.091	0.097	0.095	0.091	0.088	0.118	0.115	0.107	0.106	0.099	0.096
	50	0.091	0.087	0.094	0.090	0.100	0.097	0.091	0.089	0.118	0.115	0.109	0.108	0.101	0.098
	100	0.092	0.088	0.093	0.090	0.101	0.099	0.093	0.090	0.118	0.115	0.108	0.107	0.103	0.099
	1000	0.094	0.090	0.094	0.091	0.100	0.097	0.093	0.091	0.118	0.116	0.108	0.107	0.103	0.100
	10000	0.094	0.090	0.094	0.091	0.100	0.098	0.093	0.091	0.118	0.116	0.108	0.106	0.103	0.100

Table A.4: Average stability measures ($\bar{\rho}$) with and without Kronecker delta

Year	Sample size	Size ρ	ROSSTAT $\bar{\rho}$	ROSSTAT s_ρ	IEF OKONh $\bar{\rho}$	IEF OKONh s_ρ	IEF OKVED $\bar{\rho}$	IEF OKVED s_ρ	Rus WIOD $\bar{\rho}$	Rus WIOD s_ρ	Rus Eora $\bar{\rho}$	Rus Eora s_ρ	Ger Destatis $\bar{\rho}$	Ger Destatis s_ρ	Ger WIOD $\bar{\rho}$	Ger WIOD s_ρ
1998	10	0.1	0.084	0.03	0.094	0.026	0.1	0.026	0.091	0.029	0.120*	0.039	0.101*	0.032	0.1	0.032
		0.12	0.101	0.037	0.114	0.032	0.121*	0.031	0.11	0.036	0.146*	0.049	0.123*	0.04	0.121*	0.04
		0.15	0.127	0.049	0.143	0.041	0.153*	0.041	0.139	0.048	0.187*	0.068	0.156*	0.052	0.153*	0.053
		0.2	0.173	0.073	0.195	0.058	0.211*	0.058	0.191	0.071	0.267*	0.12	0.214*	0.077	0.211*	0.081
	20	0.1	0.088	0.025	0.097	0.023	0.098	0.021	0.093	0.023	0.118*	0.031	0.107*	0.03	0.1	0.024
		0.12	0.106	0.03	0.117	0.029	0.118	0.026	0.112	0.028	0.144*	0.039	0.130*	0.037	0.12	0.03
		0.15	0.134	0.039	0.148	0.038	0.15	0.035	0.143	0.038	0.184*	0.053	0.165*	0.049	0.153*	0.04
		0.2	0.184	0.057	0.204*	0.056	0.206*	0.052	0.197	0.057	0.261*	0.088	0.229*	0.076	0.211*	0.063
	50	0.1	0.092	0.024	0.097	0.02	0.101*	0.018	0.094	0.018	0.118*	0.026	0.108*	0.027	0.102*	0.019
		0.12	0.112	0.03	0.117	0.025	0.122*	0.023	0.114	0.022	0.143*	0.032	0.131*	0.033	0.123*	0.024
		0.15	0.142	0.039	0.148	0.033	0.155*	0.03	0.145	0.03	0.183*	0.043	0.167*	0.044	0.157*	0.032
		0.2	0.195	0.061	0.204*	0.049	0.217*	0.044	0.201*	0.045	0.258*	0.068	0.234*	0.067	0.218*	0.049
	100	0.1	0.093	0.026	0.097	0.019	0.103*	0.018	0.096	0.017	0.118*	0.024	0.108*	0.026	0.103*	0.018
		0.12	0.113	0.033	0.117	0.023	0.125*	0.022	0.116	0.021	0.144*	0.03	0.131*	0.032	0.125*	0.022
		0.15	0.143	0.048	0.147	0.03	0.161*	0.029	0.147	0.028	0.184*	0.039	0.167*	0.042	0.159*	0.029
		0.2	0.197	0.113	0.202*	0.045	0.238*	0.044	0.203*	0.042	0.258*	0.061	0.233*	0.063	0.221*	0.044
	1000	0.1	0.096	0.024	0.098	0.019	0.101*	0.019	0.096	0.016	0.119*	0.023	0.108*	0.025	0.103*	0.017
		0.12	0.116	0.031	0.118	0.023	0.123*	0.024	0.116	0.02	0.144*	0.028	0.131*	0.03	0.125*	0.021
		0.15	0.147	0.066	0.15	0.03	0.164*	0.032	0.148	0.026	0.184*	0.037	0.167*	0.04	0.159*	0.027
		0.2	0.205*	0.11	0.207*	0.046	0.235*	0.05	0.204*	0.04	0.26*	0.057	0.233*	0.06	0.221*	0.042
	10000	0.1	0.096	0.024	0.097	0.018	0.101*	0.018	0.096	0.017	0.119*	0.023	0.108*	0.024	0.103*	0.017
		0.12	0.116	0.03	0.118	0.022	0.123*	0.023	0.116	0.021	0.144*	0.028	0.13*	0.03	0.125*	0.021
		0.15	0.147	0.047	0.149	0.029	0.159*	0.03	0.148	0.027	0.184*	0.037	0.166*	0.039	0.159*	0.028
		0.2	0.204*	0.705	0.206*	0.043	0.448*	0.046	0.205*	0.041	0.262*	0.058	0.232*	0.058	0.222*	0.043
1999	10	0.1	0.086	0.03	0.095	0.026	0.1	0.026	0.093	0.03	0.119*	0.039	0.102*	0.032	0.1	0.032
		0.12	0.103	0.037	0.114	0.031	0.12	0.032	0.112	0.037	0.145*	0.049	0.123*	0.04	0.121*	0.039
		0.15	0.13	0.049	0.144	0.04	0.153*	0.041	0.142	0.048	0.186*	0.068	0.156*	0.052	0.153*	0.052
		0.2	0.176	0.073	0.196	0.057	0.211*	0.057	0.195	0.071	0.266*	0.12	0.215*	0.077	0.211*	0.08
	20	0.1	0.088	0.024	0.098	0.023	0.097	0.019	0.094	0.024	0.118*	0.031	0.107*	0.03	0.1	0.024
		0.12	0.106	0.03	0.118	0.028	0.118	0.024	0.114	0.029	0.143*	0.039	0.13*	0.037	0.12	0.03
		0.15	0.134	0.039	0.15	0.037	0.149	0.03	0.145	0.039	0.183*	0.053	0.165*	0.049	0.153*	0.04
		0.2	0.182	0.058	0.207*	0.055	0.206*	0.042	0.2	0.058	0.26*	0.089	0.23*	0.075	0.211*	0.062
	50	0.1	0.093	0.023	0.097	0.019	0.1	0.018	0.095	0.018	0.118*	0.026	0.108*	0.027	0.102*	0.019
		0.12	0.112	0.029	0.117	0.024	0.121*	0.022	0.115	0.023	0.143*	0.032	0.132*	0.034	0.123*	0.024
		0.15	0.141	0.038	0.149	0.031	0.154*	0.028	0.147	0.03	0.182*	0.043	0.168*	0.044	0.157*	0.032
		0.2	0.193	0.057	0.205*	0.047	0.214*	0.041	0.203*	0.046	0.257*	0.068	0.234*	0.067	0.218*	0.049
	100	0.1	0.094	0.022	0.096	0.018	0.101*	0.018	0.097	0.018	0.118*	0.025	0.108*	0.026	0.103*	0.018
		0.12	0.114	0.027	0.116	0.022	0.122*	0.022	0.118	0.022	0.143*	0.03	0.131*	0.032	0.125*	0.022
		0.15	0.144	0.036	0.147	0.029	0.156*	0.029	0.15	0.029	0.183*	0.04	0.167*	0.042	0.159*	0.029
		0.2	0.198	0.056	0.201*	0.044	0.218*	0.043	0.208*	0.044	0.258*	0.062	0.233*	0.063	0.221*	0.045
	1000	0.1	0.096	0.021	0.098	0.018	0.099	0.017	0.097	0.017	0.118*	0.023	0.108*	0.025	0.103*	0.017
		0.12	0.117	0.025	0.118	0.022	0.121*	0.021	0.118	0.021	0.143*	0.029	0.131*	0.03	0.125*	0.021
		0.15	0.148	0.034	0.15	0.029	0.154*	0.028	0.15	0.027	0.183*	0.038	0.167*	0.04	0.159*	0.027
		0.2	0.204*	0.058	0.207*	0.044	0.217*	0.043	0.208*	0.041	0.259*	0.058	0.233*	0.06	0.221*	0.042
	10000	0.1	0.097	0.02	0.098	0.017	0.1	0.017	0.097	0.017	0.118*	0.023	0.108*	0.024	0.103*	0.017
		0.12	0.117	0.025	0.118	0.021	0.121*	0.021	0.118	0.021	0.144*	0.029	0.131*	0.03	0.125*	0.021
		0.15	0.148	0.033	0.149	0.028	0.154*	0.028	0.15	0.028	0.184*	0.038	0.166*	0.039	0.159*	0.028
		0.2	0.204*	0.054	0.206*	0.042	0.217*	0.043	0.21*	0.046	0.261*	0.059	0.232*	0.058	0.222*	0.043

Table A.5: Average stability measures ($\bar{\rho}$) with standard deviation for different error size

Year	Sample size	Size ρ	ROSSTAT $\bar{\rho}$	ROSSTAT s_ρ	IEF OKONh $\bar{\rho}$	IEF OKONh s_ρ	IEF OKVED $\bar{\rho}$	IEF OKVED s_ρ	Rus WIOD $\bar{\rho}$	Rus WIOD s_ρ	Rus Eora $\bar{\rho}$	Rus Eora s_ρ	Ger Destatis $\bar{\rho}$	Ger Destatis s_ρ	Ger WIOD $\bar{\rho}$	Ger WIOD s_ρ
2000	10	0.1	0.086	0.026	0.094	0.025	0.1	0.031	0.092	0.029	0.12*	0.039	0.101*	0.032	0.098	0.031
		0.12	0.103	0.032	0.113	0.03	0.121*	0.038	0.111	0.036	0.147*	0.05	0.122*	0.04	0.118	0.039
		0.15	0.13	0.041	0.143	0.038	0.153*	0.049	0.14	0.047	0.188*	0.069	0.155*	0.052	0.15	0.051
		0.2	0.176	0.058	0.195	0.054	0.211*	0.073	0.193	0.07	0.269*	0.122	0.214*	0.077	0.207*	0.079
	20	0.1	0.088	0.02	0.097	0.023	0.098	0.024	0.093	0.024	0.119*	0.031	0.106*	0.03	0.098	0.024
		0.12	0.106	0.024	0.118	0.029	0.118	0.03	0.113	0.029	0.145*	0.039	0.129*	0.037	0.119	0.029
		0.15	0.134	0.031	0.149	0.037	0.15	0.039	0.144	0.039	0.185*	0.053	0.164*	0.049	0.15	0.04
		0.2	0.181	0.043	0.206*	0.055	0.207*	0.058	0.199	0.058	0.263*	0.09	0.228*	0.075	0.208*	0.063
	50	0.1	0.093	0.018	0.097	0.02	0.1	0.023	0.094	0.018	0.119*	0.026	0.108*	0.027	0.1	0.02
		0.12	0.112	0.022	0.117	0.024	0.121*	0.029	0.114	0.023	0.144*	0.032	0.131*	0.033	0.121*	0.024
		0.15	0.142	0.028	0.148	0.032	0.154*	0.038	0.145	0.03	0.184*	0.043	0.167*	0.044	0.154*	0.032
		0.2	0.194	0.041	0.205*	0.047	0.215*	0.058	0.201*	0.046	0.259*	0.069	0.233*	0.067	0.214*	0.05
	100	0.1	0.095	0.018	0.096	0.019	0.101*	0.022	0.096	0.018	0.119*	0.025	0.107*	0.025	0.102*	0.018
		0.12	0.114	0.022	0.116	0.023	0.123*	0.028	0.117	0.022	0.145*	0.03	0.13*	0.031	0.123*	0.022
		0.15	0.145	0.029	0.147	0.031	0.157*	0.036	0.148	0.029	0.185*	0.04	0.166*	0.041	0.156*	0.03
		0.2	0.199	0.043	0.202*	0.045	0.219*	0.056	0.205*	0.045	0.261*	0.063	0.231*	0.062	0.217*	0.045
	1000	0.1	0.097	0.018	0.098	0.019	0.1	0.021	0.096	0.017	0.119*	0.023	0.107*	0.024	0.102*	0.017
		0.12	0.117	0.022	0.118	0.023	0.121*	0.025	0.117	0.021	0.145*	0.029	0.13*	0.03	0.123*	0.021
		0.15	0.149	0.029	0.15	0.03	0.154*	0.034	0.148	0.027	0.185*	0.038	0.165*	0.039	0.157*	0.028
		0.2	0.205*	0.043	0.207*	0.045	0.22*	0.062	0.206*	0.041	0.262*	0.058	0.231*	0.059	0.218*	0.042
	10000	0.1	0.097	0.017	0.097	0.018	0.1	0.021	0.096	0.017	0.119*	0.023	0.107*	0.024	0.102*	0.017
		0.12	0.117	0.021	0.118	0.022	0.121*	0.025	0.117	0.021	0.145*	0.029	0.129*	0.029	0.124*	0.021
		0.15	0.148	0.028	0.149	0.029	0.155*	0.033	0.148	0.028	0.186*	0.038	0.165*	0.038	0.157*	0.028
		0.2	0.205*	0.043	0.205*	0.042	0.219*	0.055	0.206*	0.043	0.264*	0.059	0.23*	0.058	0.219*	0.044
2001	10	0.1	0.083	0.026	0.091	0.024	0.1	0.03	0.089	0.029	0.119*	0.039	0.101*	0.032	0.098	0.031
		0.12	0.1	0.032	0.11	0.029	0.12	0.037	0.108	0.035	0.145*	0.049	0.123*	0.04	0.118	0.039
		0.15	0.126	0.041	0.139	0.037	0.153*	0.049	0.136	0.046	0.187*	0.068	0.155*	0.052	0.15	0.051
		0.2	0.171	0.059	0.19	0.052	0.211*	0.073	0.187	0.067	0.266*	0.12	0.214*	0.077	0.207*	0.08
	20	0.1	0.086	0.02	0.095	0.023	0.098	0.024	0.091	0.023	0.118*	0.031	0.107*	0.03	0.098	0.024
		0.12	0.103	0.025	0.115	0.028	0.118	0.03	0.11	0.028	0.143*	0.039	0.129*	0.037	0.119	0.029
		0.15	0.13	0.032	0.146	0.037	0.15	0.039	0.14	0.037	0.183*	0.053	0.164*	0.049	0.151*	0.04
		0.2	0.177	0.044	0.201*	0.055	0.207*	0.058	0.193	0.055	0.26*	0.088	0.228*	0.075	0.208*	0.063
	50	0.1	0.091	0.018	0.094	0.02	0.1	0.023	0.092	0.018	0.118*	0.026	0.108*	0.027	0.1	0.019
		0.12	0.11	0.022	0.114	0.024	0.121*	0.029	0.111	0.022	0.143*	0.032	0.131*	0.033	0.121*	0.024
		0.15	0.139	0.029	0.145	0.032	0.154*	0.038	0.141	0.029	0.182*	0.043	0.167*	0.044	0.154*	0.032
		0.2	0.19	0.042	0.199	0.047	0.214*	0.058	0.195	0.044	0.257*	0.068	0.233*	0.066	0.215*	0.05
	100	0.1	0.092	0.018	0.094	0.019	0.101*	0.023	0.094	0.017	0.118*	0.024	0.107*	0.025	0.102*	0.018
		0.12	0.111	0.022	0.113	0.024	0.123*	0.028	0.113	0.021	0.143*	0.03	0.13*	0.031	0.123*	0.022
		0.15	0.141	0.029	0.143	0.031	0.156*	0.037	0.144	0.027	0.183*	0.04	0.166*	0.041	0.157*	0.03
		0.2	0.194	0.044	0.196	0.045	0.219*	0.057	0.199	0.041	0.257*	0.061	0.231*	0.062	0.217*	0.045
	1000	0.1	0.095	0.018	0.095	0.019	0.1	0.021	0.094	0.016	0.118*	0.023	0.107*	0.024	0.102*	0.017
		0.12	0.115	0.022	0.115	0.023	0.121*	0.026	0.114	0.02	0.143*	0.029	0.13*	0.03	0.124*	0.021
		0.15	0.145	0.029	0.146	0.03	0.154*	0.034	0.144	0.026	0.183*	0.038	0.166*	0.039	0.157*	0.028
		0.2	0.201*	0.044	0.201*	0.045	0.225*	0.085	0.2	0.039	0.259*	0.058	0.232*	0.059	0.218*	0.042
	10000	0.1	0.095	0.018	0.095	0.018	0.1	0.021	0.094	0.016	0.118*	0.023	0.107*	0.024	0.102*	0.017
		0.12	0.115	0.022	0.115	0.022	0.121*	0.026	0.114	0.02	0.144*	0.029	0.13*	0.029	0.124*	0.021
		0.15	0.145	0.029	0.145	0.029	0.154*	0.034	0.144	0.026	0.184*	0.038	0.165*	0.038	0.158*	0.028
		0.2	0.201*	0.043	0.2	0.043	0.219*	0.059	0.2	0.04	0.261*	0.059	0.23*	0.058	0.22*	0.044

Average stability ρ with standard deviation for different error size - continued

Year	Sample size	Size ρ	ROSSTAT $\bar{\rho}$	ROSSTAT s_ρ	IEF OKONh $\bar{\rho}$	IEF OKONh s_ρ	IEF OKVED $\bar{\rho}$	IEF OKVED s_ρ	Rus WIOD $\bar{\rho}$	Rus WIOD s_ρ	Rus Eora $\bar{\rho}$	Rus Eora s_ρ	Ger Destatis $\bar{\rho}$	Ger Destatis s_ρ	Ger WIOD $\bar{\rho}$	Ger WIOD s_ρ
2002	10	0.1	0.084	0.026	0.093	0.024	0.099	0.03	0.089	0.029	0.12*	0.039	0.102*	0.032	0.098	0.031
		0.12	0.101	0.032	0.112	0.029	0.12	0.037	0.108	0.035	0.146*	0.049	0.123*	0.04	0.119	0.039
		0.15	0.127	0.041	0.141	0.038	0.152*	0.048	0.136	0.046	0.187*	0.068	0.156*	0.052	0.151*	0.052
		0.2	0.172	0.058	0.192	0.053	0.21*	0.072	0.186	0.068	0.267*	0.12	0.215*	0.078	0.208*	0.081
	20	0.1	0.086	0.02	0.095	0.023	0.097	0.024	0.091	0.023	0.118*	0.031	0.107*	0.03	0.099	0.024
		0.12	0.103	0.024	0.115	0.028	0.118	0.03	0.11	0.028	0.144*	0.039	0.13*	0.037	0.119	0.03
		0.15	0.13	0.031	0.146	0.037	0.149	0.039	0.139	0.037	0.184*	0.053	0.165*	0.049	0.152*	0.04
		0.2	0.177	0.043	0.202*	0.055	0.206*	0.057	0.193	0.056	0.261*	0.088	0.23*	0.075	0.21*	0.064
	50	0.1	0.091	0.018	0.094	0.02	0.1	0.023	0.092	0.018	0.118*	0.026	0.108*	0.027	0.101*	0.02
		0.12	0.11	0.022	0.114	0.024	0.121*	0.029	0.111	0.022	0.143*	0.032	0.131*	0.033	0.122*	0.024
		0.15	0.139	0.028	0.145	0.032	0.154*	0.038	0.141	0.029	0.183*	0.043	0.168*	0.044	0.155*	0.032
		0.2	0.19	0.041	0.199	0.047	0.214*	0.057	0.195	0.044	0.257*	0.068	0.234*	0.067	0.216*	0.05
	100	0.1	0.092	0.018	0.094	0.019	0.101*	0.023	0.093	0.017	0.118*	0.024	0.108*	0.025	0.102*	0.018
		0.12	0.111	0.022	0.113	0.023	0.123*	0.029	0.113	0.021	0.144*	0.03	0.131*	0.031	0.124*	0.022
		0.15	0.141	0.028	0.143	0.03	0.157*	0.038	0.143	0.027	0.184*	0.039	0.167*	0.041	0.158*	0.03
		0.2	0.193	0.042	0.196	0.044	0.22*	0.061	0.198	0.041	0.258*	0.061	0.233*	0.062	0.219*	0.045
	1000	0.1	0.095	0.018	0.095	0.018	0.1	0.021	0.094	0.016	0.119*	0.023	0.108*	0.024	0.103*	0.017
		0.12	0.115	0.022	0.115	0.022	0.121*	0.026	0.113	0.02	0.144*	0.028	0.131*	0.03	0.124*	0.021
		0.15	0.145	0.028	0.146	0.029	0.154*	0.036	0.144	0.026	0.184*	0.037	0.166*	0.039	0.158*	0.028
		0.2	0.201*	0.043	0.2	0.043	0.244*	0.164	0.199	0.039	0.26*	0.057	0.233*	0.059	0.22*	0.042
	10000	0.1	0.095	0.017	0.095	0.018	0.1	0.021	0.094	0.016	0.119*	0.023	0.108*	0.024	0.103*	0.017
		0.12	0.115	0.021	0.115	0.022	0.121*	0.026	0.113	0.02	0.144*	0.028	0.13*	0.03	0.125*	0.021
		0.15	0.145	0.028	0.145	0.028	0.154*	0.035	0.144	0.027	0.184*	0.037	0.166*	0.039	0.159*	0.028
		0.2	0.201*	0.042	0.2	0.041	0.225*	0.08	0.199	0.04	0.262*	0.058	0.232*	0.058	0.221*	0.044
2003	10	0.1	0.083	0.026	0.093	0.025	0.099	0.03	0.089	0.029	0.119*	0.039	0.103*	0.033	0.098	0.032
		0.12	0.1	0.032	0.112	0.03	0.12	0.037	0.107	0.035	0.145*	0.049	0.124*	0.041	0.119	0.039
		0.15	0.126	0.041	0.142	0.038	0.152*	0.048	0.136	0.046	0.187*	0.068	0.157*	0.054	0.151*	0.052
		0.2	0.17	0.058	0.193	0.055	0.209*	0.071	0.186	0.068	0.266*	0.118	0.217*	0.08	0.209*	0.082
	20	0.1	0.085	0.02	0.094	0.023	0.097	0.024	0.091	0.023	0.118*	0.031	0.107*	0.031	0.099	0.024
		0.12	0.103	0.024	0.114	0.028	0.118	0.029	0.11	0.028	0.143*	0.039	0.13*	0.038	0.12	0.03
		0.15	0.129	0.031	0.145	0.037	0.149	0.038	0.139	0.037	0.184*	0.053	0.166*	0.05	0.152*	0.04
		0.2	0.175	0.044	0.201*	0.055	0.205*	0.056	0.192	0.056	0.26*	0.087	0.23*	0.075	0.21*	0.064
	50	0.1	0.091	0.018	0.094	0.02	0.1	0.024	0.091	0.018	0.118*	0.026	0.109*	0.029	0.101*	0.019
		0.12	0.109	0.022	0.114	0.024	0.121*	0.029	0.111	0.022	0.143*	0.032	0.132*	0.035	0.122*	0.024
		0.15	0.138	0.029	0.144	0.032	0.154*	0.038	0.141	0.029	0.182*	0.043	0.169*	0.046	0.156*	0.032
		0.2	0.189	0.042	0.198	0.047	0.214*	0.058	0.194	0.044	0.257*	0.068	0.236*	0.07	0.216*	0.05
	100	0.1	0.092	0.018	0.093	0.019	0.101*	0.024	0.093	0.017	0.118*	0.024	0.108*	0.026	0.103*	0.018
		0.12	0.111	0.022	0.112	0.023	0.123*	0.03	0.113	0.021	0.143*	0.03	0.131*	0.032	0.124*	0.022
		0.15	0.14	0.029	0.142	0.03	0.157*	0.04	0.143	0.028	0.183*	0.04	0.167*	0.042	0.158*	0.029
		0.2	0.192	0.043	0.195	0.044	0.222*	0.069	0.197	0.041	0.257*	0.061	0.234*	0.063	0.219*	0.045
	1000	0.1	0.094	0.018	0.094	0.018	0.1	0.022	0.093	0.016	0.118*	0.023	0.108*	0.025	0.103*	0.017
		0.12	0.114	0.022	0.114	0.022	0.121*	0.028	0.113	0.02	0.143*	0.028	0.131*	0.03	0.125*	0.021
		0.15	0.145	0.029	0.145	0.029	0.155*	0.039	0.143	0.026	0.183*	0.037	0.167*	0.04	0.158*	0.028
		0.2	0.2	0.043	0.199	0.043	0.22*	0.069	0.198	0.039	0.259*	0.057	0.234*	0.06	0.22*	0.042
	10000	0.1	0.094	0.017	0.094	0.018	0.1	0.022	0.093	0.017	0.118*	0.023	0.108*	0.024	0.103*	0.017
		0.12	0.114	0.021	0.114	0.021	0.121*	0.027	0.113	0.02	0.144*	0.029	0.131*	0.03	0.125*	0.021
		0.15	0.145	0.028	0.144	0.028	0.155*	0.037	0.143	0.027	0.184*	0.038	0.167*	0.039	0.159*	0.028
		0.2	0.2	0.042	0.198	0.041	0.254*	0.183	0.198	0.041	0.261*	0.059	0.233*	0.059	0.222*	0.044

Average stability ρ with standard deviation for different error size - continued

		Year = 1998						Year = 1999					
		10	20	50	100	1000	10000	10	20	50	100	1000	10000
Average bias ($\bar{b}$) and standard deviation (s_b)													
Russia IEF	n=44	0.00024	0.00031	0.00022	0.00027	0.00027	0.00030	0.00021	0.00024	0.00016	0.00019	0.00018	0.00021
OKVED		0.00285	0.00235	0.00149	0.00109	0.00069	0.00073	0.00253	0.00174	0.00109	0.00077	0.00041	0.00041
	n=34	0.00030	0.00007	0.00032	0.00016	0.00033	0.00037	0.00018	0.00013	0.00027	0.00020	0.00023	0.00025
		0.00327	0.00224	0.00197	0.00162	0.00077	0.00086	0.00245	0.00199	0.00153	0.00098	0.00045	0.00049
	n=22	0.00033	0.00006	0.00036	0.00015	0.00052	0.00052	0.00005	-0.00010	0.00021	0.00014	0.00037	0.00038
		0.00508	0.00265	0.00205	0.00128	0.00105	0.00096	0.00292	0.00195	0.00175	0.00113	0.00062	0.00057
Russia	n=47	0.00008	0.00013	0.00013	0.00011	0.00008	0.00007	0.00007	0.00012	0.00012	0.00010	0.00008	0.00007
Eora		0.00096	0.00083	0.00064	0.00051	0.00023	0.00020	0.00094	0.00080	0.00060	0.00048	0.00023	0.00019
	n=34	-0.00001	-0.00001	0.00012	0.00014	0.00011	0.00011	0.00000	-0.00001	0.00012	0.00013	0.00011	0.00011
		0.00148	0.00089	0.00058	0.00054	0.00034	0.00028	0.00139	0.00085	0.00056	0.00052	0.00034	0.00027
	n=22	-0.00017	0.00008	0.00009	0.00013	0.00017	0.00015	-0.00017	0.00008	0.00009	0.00013	0.00016	0.00015
		0.00183	0.00146	0.00092	0.00068	0.00037	0.00031	0.00173	0.00142	0.00089	0.00066	0.00036	0.00031
Germany	n=67	0.00002	-0.00005	0.00009	0.00011	0.00011	0.00014	0.00002	-0.00005	0.00009	0.00012	0.00012	0.00014
DESTATIS		0.00164	0.00128	0.00096	0.00067	0.00039	0.00029	0.00166	0.00130	0.00097	0.00067	0.00039	0.00030
	n=34	0.00002	-0.00005	0.00009	0.00011	0.00011	0.00014	0.00002	-0.00005	0.00009	0.00012	0.00012	0.00014
		0.00164	0.00128	0.00096	0.00067	0.00039	0.00029	0.00166	0.00130	0.00097	0.00067	0.00039	0.00030
	n=22	-0.00014	0.00001	0.00011	0.00007	0.00023	0.00025	-0.00016	0.00001	0.00011	0.00007	0.00023	0.00025
		0.00239	0.00195	0.00120	0.00106	0.00043	0.00043	0.00240	0.00186	0.00127	0.00100	0.00045	0.00044
Average t-statistic ($\bar{t}$), standard deviation (s_t) and percentage "significant"													
Russia IEF	n=44	0.283	0.368	0.444	0.840	2.848	9.070	0.290	0.389	0.471	0.762	2.568	8.227
OKVED		1.144	1.045	1.007	0.938	1.418	3.307	1.174	1.054	1.030	0.928	1.357	2.956
		6%	5%	6%	11%	73%	99%	7%	6%	7%	9%	66%	98%
	n=36	0.234	0.347	0.790	0.924	2.951	9.045	0.168	0.253	0.656	0.818	2.670	8.269
		1.072	1.183	1.153	1.053	1.295	3.315	1.085	1.180	1.135	1.041	1.196	3.011
		5%	9%	16%	16%	77%	98%	4%	8%	12%	13%	71%	97%
	n=25	0.063	0.178	0.583	0.585	2.792	8.913	0.052	0.173	0.486	0.521	2.484	7.914
		1.009	0.920	1.109	1.159	1.268	3.323	1.025	0.926	1.088	1.151	1.195	2.839
		4%	2%	10%	12%	74%	98%	5%	3%	9%	11%	66%	98%
Russia	n=47	0.316	0.509	0.805	0.989	2.625	7.347	0.322	0.513	0.811	0.988	2.622	7.336
Eora		1.002	1.066	1.001	1.008	1.220	2.650	1.003	1.068	1.001	1.007	1.223	2.662
		3%	7%	11%	17%	71%	97%	3%	7%	12%	17%	71%	97%
	n=34	-0.023	-0.006	0.407	0.636	1.852	7.242	-0.023	-0.007	0.410	0.635	1.836	7.179
		1.069	1.031	0.944	0.995	1.187	2.490	1.069	1.032	0.945	0.995	1.189	2.509
		4%	5%	5%	9%	45%	99%	4%	5%	4%	9%	44%	98%
	n=25	-0.042	0.274	0.530	0.809	2.470	7.183	-0.052	0.273	0.532	0.812	2.455	7.152
		1.152	0.997	1.049	1.129	1.163	2.615	1.151	0.997	1.046	1.124	1.165	2.623
		6%	5%	8%	14%	67%	98%	6%	5%	8%	14%	66%	98%
Germany	n=57	0.348	0.506	0.828	1.113	2.622	8.029	0.355	0.515	0.825	1.119	2.626	8.061
Destatis		1.211	1.152	0.982	1.027	1.317	2.920	1.213	1.152	0.981	1.024	1.320	2.916
		7%	10%	12%	20%	69%	99%	8%	10%	12%	20%	69%	99%
	n=34	-0.054	-0.268	0.247	0.483	1.736	7.383	-0.053	-0.259	0.248	0.488	1.728	7.351
		1.008	1.041	1.040	0.963	1.200	2.756	1.002	1.045	1.039	0.962	1.200	2.762
		3%	6%	6%	7%	42%	97%	3%	6%	6%	7%	41%	97%
	n=22	-0.114	-0.080	0.361	0.457	2.064	7.565	-0.103	-0.071	0.365	0.483	2.078	7.554
		0.964	0.951	0.970	0.999	1.114	2.630	0.967	0.955	0.970	1.016	1.102	2.634
		4%	3%	7%	9%	54%	98%	4%	3%	7%	10%	55%	99%
The stability measures ($\bar{\rho}$) and standard deviations (s_ρ)													
Russia IEF	n=44	0.1	0.098	0.101*	0.103*	0.101*	0.101*	0.1	0.097	0.1	0.101*	0.099	0.1
OKVED		0.03	0.025	0.024	0.026	0.024	0.024	0.03	0.024	0.023	0.022	0.021	0.02
	n=36	0.091	0.095	0.099	0.099	0.099	0.1	0.089	0.093	0.098	0.098	0.098	0.099
		0.035	0.034	0.028	0.025	0.023	0.024	0.03	0.026	0.023	0.021	0.02	0.02
	n=22	0.097	0.099	0.102*	0.102*	0.103*	0.103*	0.096	0.097	0.099	0.099	0.101*	0.101*
		0.029	0.026	0.03	0.026	0.027	0.026	0.028	0.025	0.024	0.022	0.021	0.02
Russia	n=47	0.12 *	0.118 *	0.118 *	0.118 *	0.119 *	0.119 *	0.119 *	0.118 *	0.118 *	0.118 *	0.118 *	0.118 *
Eora		0.039	0.031	0.026	0.024	0.023	0.023	0.039	0.031	0.026	0.025	0.023	0.023
	n=34	0.111 *	0.112 *	0.116 *	0.117 *	0.118 *	0.119 *	0.111 *	0.112 *	0.116 *	0.116 *	0.117 *	0.118 *
		0.032	0.028	0.024	0.023	0.022	0.022	0.032	0.028	0.024	0.023	0.023	0.023
	n=22	0.107 *	0.11 *	0.111 *	0.111 *	0.112 *	0.112 *	0.106 *	0.11 *	0.111 *	0.111 *	0.111 *	0.111 *
		0.03	0.026	0.022	0.019	0.019	0.019	0.03	0.027	0.022	0.019	0.019	0.019
Germany	n=67	0.101 *	0.107	0.108	0.108	0.108	0.108	0.102	0.107	0.108	0.108	0.108	0.108*
DESTATIS		0.032	0.03	0.027	0.026	0.025	0.024	0.032	0.03	0.027	0.026	0.025	0.024
	n=34	0.101 *	0.101 *	0.105 *	0.106 *	0.106 *	0.106 *	0.1 *	0.101 *	0.105 *	0.106 *	0.106 *	0.106 *
		0.03	0.026	0.024	0.023	0.021	0.021	0.03	0.025	0.024	0.023	0.021	0.021
	n=22	0.101 *	0.103 *	0.107 *	0.106 *	0.108 *	0.108 *	0.102 *	0.104 *	0.107 *	0.107 *	0.109 *	0.109 *
		0.027	0.023	0.021	0.019	0.017	0.017	0.028	0.023	0.021	0.019	0.017	0.017

Table A.6: Monte Carlo simulation results for varying size n

		Year = 2000						Year = 2001					
		10	20	50	100	1000	10000	10	20	50	100	1000	10000
		Average bias ($\bar{b}$) and standard deviation (s_b)											
Russia IEF	n=44	0.00020	0.00024	0.00015	0.00018	0.00019	0.00021	0.00017	0.00024	0.00014	0.00018	0.00018	0.00021
OKVED		0.00260	0.00177	0.00110	0.00077	0.00042	0.00043	0.00235	0.00173	0.00106	0.00070	0.00038	0.00041
	n=34	0.00018	0.00012	0.00025	0.00019	0.00023	0.00026	0.00015	0.00011	0.00025	0.00019	0.00022	0.00024
		0.00250	0.00204	0.00154	0.00097	0.00046	0.00050	0.00227	0.00188	0.00146	0.00093	0.00044	0.00046
	n=22	0.00007	-0.00008	0.00023	0.00016	0.00039	0.00039	0.00009	-0.00006	0.00026	0.00018	0.00039	0.00039
		0.00292	0.00197	0.00175	0.00112	0.00064	0.00060	0.00289	0.00192	0.00172	0.00109	0.00063	0.00059
Russia	n=47	0.00008	0.00013	0.00013	0.00012	0.00008	0.00007	0.00008	0.00013	0.00014	0.00012	0.00008	0.00007
Eora		0.00104	0.00089	0.00071	0.00056	0.00025	0.00021	0.00105	0.00091	0.00072	0.00058	0.00025	0.00021
	n=34	-0.00003	-0.00002	0.00012	0.00014	0.00012	0.00012	-0.00002	-0.00002	0.00013	0.00014	0.00012	0.00012
		0.00162	0.00098	0.00061	0.00058	0.00036	0.00029	0.00165	0.00099	0.00061	0.00059	0.00035	0.00029
	n=22	-0.00019	0.00008	0.00009	0.00014	0.00018	0.00016	-0.00020	0.00006	0.00009	0.00014	0.00018	0.00016
		0.00200	0.00155	0.00100	0.00074	0.00039	0.00033	0.00202	0.00157	0.00102	0.00075	0.00040	0.00033
Germany	n=67	0.00001	-0.00005	0.00009	0.00011	0.00011	0.00014	0.00000	-0.00004	0.00009	0.00011	0.00011	0.00014
DESTATIS		0.00169	0.00132	0.00098	0.00067	0.00036	0.00029	0.00170	0.00133	0.00100	0.00068	0.00036	0.00029
	n=34	0.00001	-0.00005	0.00009	0.00011	0.00011	0.00014	0.00000	-0.00004	0.00009	0.00011	0.00011	0.00014
		0.00169	0.00132	0.00098	0.00067	0.00036	0.00029	0.00170	0.00133	0.00100	0.00068	0.00036	0.00029
	n=22	-0.00014	0.00000	0.00010	0.00006	0.00023	0.00025	-0.00014	0.00001	0.00011	0.00007	0.00023	0.00025
		0.00243	0.00191	0.00131	0.00103	0.00044	0.00043	0.00248	0.00193	0.00131	0.00104	0.00045	0.00043
		Average t-statistic ($\bar{t}$), standard deviation (s_t) and percentage "significant"											
Russia IEF	n=44	0.307	0.413	0.467	0.758	2.582	8.289	0.314	0.420	0.475	0.769	2.598	8.327
OKVED		1.171	1.054	1.034	0.925	1.358	2.972	1.162	1.049	1.031	0.921	1.360	2.991
		7%	6%	7%	9%	67%	98%	7%	6%	7%	9%	67%	98%
	n=36	0.166	0.248	0.645	0.817	2.661	8.291	0.169	0.254	0.644	0.824	2.671	8.329
		1.080	1.178	1.135	1.037	1.201	3.025	1.086	1.178	1.131	1.034	1.207	3.034
		4%	8%	12%	13%	71%	97%	4%	8%	13%	13%	71%	98%
	n=25	0.070	0.192	0.504	0.553	2.508	7.964	0.082	0.194	0.517	0.577	2.503	7.987
		1.026	0.929	1.079	1.144	1.191	2.845	1.021	0.926	1.078	1.142	1.191	2.849
		4%	3%	9%	11%	66%	99%	4%	3%	9%	11%	66%	99%
Russia	n=47	0.313	0.512	0.814	0.996	2.661	7.454	0.313	0.507	0.806	0.987	2.622	7.349
Eora		0.998	1.063	1.002	1.005	1.205	2.648	1.002	1.064	1.001	1.009	1.222	2.678
		3%	7%	12%	17%	72%	97%	3%	7%	11%	17%	71%	97%
	n=34	-0.030	0.005	0.415	0.646	1.885	7.291	-0.026	-0.001	0.419	0.641	1.874	7.252
		1.076	1.032	0.942	0.994	1.197	2.491	1.075	1.033	0.946	0.996	1.189	2.525
		4%	5%	5%	9%	46%	99%	4%	5%	5%	10%	46%	98%
	n=25	-0.040	0.274	0.530	0.814	2.476	7.203	-0.054	0.258	0.518	0.804	2.465	7.182
		1.149	0.998	1.053	1.128	1.165	2.635	1.147	0.996	1.049	1.127	1.173	2.651
		6%	5%	8%	15%	66%	98%	6%	5%	8%	14%	66%	98%
Germany	n=57	0.371	0.516	0.820	1.110	2.620	8.022	0.364	0.509	0.822	1.119	2.645	8.060
DESTATIS		1.228	1.171	0.992	1.032	1.326	2.905	1.231	1.170	0.990	1.035	1.335	2.918
		8%	11%	12%	20%	69%	99%	8%	11%	12%	21%	69%	99%
	n=34	-0.080	-0.254	0.252	0.490	1.729	7.396	-0.088	-0.248	0.254	0.494	1.731	7.433
		1.010	1.051	1.036	0.957	1.193	2.752	1.006	1.050	1.032	0.954	1.187	2.754
		3%	6%	6%	7%	42%	98%	3%	6%	6%	7%	42%	98%
	n=22	-0.098	-0.070	0.374	0.477	2.055	7.458	-0.096	-0.065	0.377	0.470	2.052	7.482
		0.971	0.959	0.979	1.020	1.092	2.586	0.978	0.969	0.982	1.017	1.091	2.594
		4%	3%	8%	9%	54%	98%	4%	3%	7%	9%	54%	98%
		The stability measures ($\bar{\rho}$) and standard deviations (s_ρ)											
Russia IEF	n=44	0.1	0.098	0.1	0.101*	0.1	0.1	0.1	0.098	0.1	0.101*	0.1	0.1
OKVED		0.031	0.024	0.023	0.022	0.021	0.021	0.03	0.024	0.023	0.023	0.021	0.021
	n=36	0.09	0.094	0.098	0.099	0.099	0.099	0.09	0.094	0.098	0.099	0.099	0.099
		0.03	0.026	0.023	0.021	0.02	0.02	0.031	0.027	0.024	0.021	0.02	0.02
	n=22	0.096	0.098	0.099	0.1	0.101*	0.101*	0.096	0.097	0.099	0.1	0.101*	0.101*
		0.028	0.025	0.024	0.022	0.021	0.02	0.028	0.025	0.024	0.022	0.021	0.02
Russia	n=47	0.12*	0.119*	0.119*	0.119*	0.119*	0.119*	0.119*	0.118*	0.118*	0.118*	0.118*	0.118*
Eora		0.039	0.031	0.026	0.025	0.023	0.023	0.039	0.031	0.026	0.024	0.023	0.023
	n=34	0.113*	0.114*	0.118*	0.118*	0.12*	0.12*	0.111*	0.112*	0.116*	0.117*	0.118*	0.118*
		0.032	0.027	0.024	0.023	0.022	0.022	0.032	0.028	0.024	0.023	0.022	0.022
	n=22	0.107*	0.11*	0.111*	0.111*	0.112*	0.112*	0.106*	0.11*	0.111*	0.111*	0.112*	0.112*
		0.031	0.027	0.022	0.02	0.02	0.019	0.03	0.026	0.022	0.019	0.019	0.019
Germany	n=67	0.101*	0.106*	0.108*	0.107*	0.107*	0.107*	0.101*	0.107*	0.108*	0.107*	0.107*	0.107*
DESTATIS		0.032	0.03	0.027	0.025	0.024	0.024	0.032	0.03	0.027	0.025	0.024	0.024
	n=34	0.099	0.1	0.104*	0.104*	0.105*	0.105*	0.1	0.1	0.104*	0.104*	0.105*	0.105*
		0.029	0.024	0.023	0.022	0.02	0.019	0.029	0.024	0.023	0.022	0.02	0.019
	n=22	0.102*	0.103*	0.107*	0.106*	0.109*	0.108*	0.102*	0.103*	0.107*	0.106*	0.109*	0.109*
		0.029	0.023	0.021	0.019	0.017	0.017	0.028	0.023	0.021	0.019	0.017	0.017

MC simulation results for varying size n - continued

		Year = 2002						Year = 2003					
		10	20	50	100	1000	10000	10	20	50	100	1000	10000
Average bias ($\bar{b}$) and standard deviation (s_b)													
Russia IEF	n=44	0.00017	0.00022	0.00012	0.00017	0.00018	0.00020	0.00017	0.00020	0.00012	0.00017	0.00018	0.00020
OKVED		0.00224	0.00157	0.00099	0.00068	0.00040	0.00041	0.00216	0.00154	0.00098	0.00068	0.00041	0.00042
	n=34	0.00020	0.00014	0.00027	0.00020	0.00023	0.00024	0.00020	0.00016	0.00029	0.00021	0.00023	0.00025
		0.00225	0.00187	0.00149	0.00090	0.00047	0.00047	0.00218	0.00184	0.00150	0.00091	0.00048	0.00049
	n=22	0.00002	-0.00009	0.00023	0.00016	0.00039	0.00040	0.00001	-0.00006	0.00026	0.00017	0.00040	0.00041
		0.00289	0.00200	0.00179	0.00112	0.00066	0.00063	0.00292	0.00198	0.00183	0.00111	0.00068	0.00067
Russia	n=47	0.00008	0.00014	0.00014	0.00012	0.00009	0.00008	0.00007	0.00013	0.00014	0.00012	0.00008	0.00007
Eora		0.00110	0.00096	0.00078	0.00062	0.00026	0.00022	0.00113	0.00099	0.00082	0.00065	0.00026	0.00022
	n=34	-0.00002	-0.00002	0.00013	0.00015	0.00012	0.00012	-0.00003	-0.00003	0.00013	0.00014	0.00012	0.00012
		0.00177	0.00106	0.00064	0.00062	0.00036	0.00030	0.00185	0.00110	0.00064	0.00064	0.00036	0.00030
	n=22	-0.00021	0.00007	0.00009	0.00015	0.00019	0.00017	-0.00023	0.00005	0.00008	0.00014	0.00019	0.00017
		0.00217	0.00165	0.00107	0.00079	0.00042	0.00035	0.00227	0.00170	0.00111	0.00082	0.00042	0.00035
Germany	n=67	0.00000	-0.00004	0.00008	0.00012	0.00011	0.00014	0.00000	-0.00003	0.00009	0.00012	0.00011	0.00014
DESTATIS		0.00165	0.00133	0.00101	0.00070	0.00037	0.00030	0.00167	0.00136	0.00100	0.00070	0.00037	0.00030
	n=34	0.00000	-0.00004	0.00008	0.00012	0.00011	0.00014	0.00000	-0.00003	0.00009	0.00012	0.00011	0.00014
		0.00165	0.00133	0.00101	0.00070	0.00037	0.00030	0.00167	0.00136	0.00100	0.00070	0.00037	0.00030
	n=22	-0.00014	0.00002	0.00011	0.00007	0.00022	0.00025	-0.00014	0.00003	0.00011	0.00007	0.00023	0.00025
		0.00249	0.00192	0.00129	0.00104	0.00045	0.00043	0.00256	0.00197	0.00132	0.00105	0.00046	0.00044
Average t-statistic ($\bar{t}$), standard deviation (s_t) and percentage "significant"													
Russia IEF	n=44	0.314	0.407	0.437	0.755	2.602	8.430	0.311	0.399	0.436	0.768	2.666	8.658
OKVED		1.149	1.042	1.030	0.928	1.374	3.037	1.131	1.035	1.024	0.930	1.387	3.110
		7%	5%	7%	9%	67%	99%	7%	5%	7%	10%	68%	99%
	n=36	0.207	0.295	0.669	0.833	2.700	8.445	0.233	0.320	0.704	0.868	2.767	8.680
		1.089	1.167	1.136	1.042	1.220	3.066	1.092	1.165	1.140	1.047	1.246	3.113
		4%	8%	13%	13%	71%	98%	5%	9%	14%	14%	72%	98%
	n=25	0.050	0.193	0.515	0.571	2.542	8.112	0.060	0.216	0.542	0.589	2.606	8.371
		1.016	0.924	1.080	1.145	1.199	2.907	1.008	0.918	1.084	1.149	1.213	3.004
		4%	3%	9%	11%	68%	99%	4%	2%	9%	12%	69%	99%
Russia	n=47	0.311	0.507	0.804	0.991	2.629	7.364	0.310	0.506	0.804	0.986	2.612	7.318
Eora		1.000	1.064	1.002	1.009	1.221	2.668	1.003	1.064	1.002	1.010	1.225	2.687
		3%	7%	11%	17%	71%	97%	3%	7%	11%	17%	71%	97%
	n=34	-0.026	-0.003	0.415	0.642	1.885	7.303	-0.027	-0.006	0.417	0.636	1.877	7.259
		1.074	1.032	0.944	0.997	1.188	2.507	1.076	1.034	0.948	1.000	1.186	2.529
		4%	5%	5%	10%	46%	99%	4%	5%	5%	10%	46%	98%
	n=25	-0.049	0.262	0.519	0.809	2.488	7.218	-0.054	0.255	0.511	0.802	2.475	7.195
		1.149	0.995	1.051	1.130	1.170	2.640	1.148	0.995	1.051	1.129	1.175	2.657
		6%	5%	8%	14%	68%	98%	6%	5%	7%	14%	67%	98%
Germany	n=57	0.364	0.516	0.831	1.133	2.660	8.102	0.374	0.510	0.828	1.127	2.670	8.145
DESTATIS		1.232	1.172	0.991	1.035	1.336	2.927	1.220	1.171	1.002	1.059	1.344	2.947
		8%	11%	12%	21%	70%	99%	8%	11%	13%	21%	70%	99%
	n=34	-0.094	-0.256	0.238	0.490	1.747	7.499	-0.088	-0.257	0.237	0.502	1.742	7.498
		1.003	1.052	1.027	0.952	1.187	2.756	1.002	1.052	1.024	0.949	1.190	2.777
		3%	6%	6%	7%	43%	98%	3%	6%	6%	6%	43%	98%
	n=22	-0.086	-0.058	0.379	0.473	2.062	7.489	-0.087	-0.049	0.386	0.474	2.062	7.519
		0.973	0.962	0.977	1.001	1.094	2.586	0.976	0.966	0.971	0.997	1.095	2.620
		4%	3%	7%	9%	55%	98%	4%	4%	7%	9%	55%	98%
The stability measures ($\bar{\rho}$) and standard deviations (s_ρ)													
Russia IEF	n=44	0.099	0.097	0.100	0.101*	0.100	0.100	0.099	0.097	0.100	0.101*	0.100	0.100
OKVED		0.030	0.024	0.023	0.023	0.021	0.021	0.030	0.024	0.024	0.024	0.022	0.022
	n=36	0.090	0.094	0.098	0.098	0.098	0.099	0.090	0.094	0.098	0.098	0.098	0.099
		0.031	0.028	0.024	0.022	0.021	0.021	0.032	0.029	0.025	0.023	0.021	0.022
	n=22	0.096	0.098	0.099	0.099	0.101 *	0.101 *	0.097	0.098	0.100	0.099	0.101 *	0.101 *
		0.028	0.025	0.025	0.023	0.022	0.021	0.028	0.025	0.026	0.023	0.023	0.023
Russia	n=47	0.120*	0.118*	0.118*	0.118*	0.119*	0.119*	0.119*	0.118*	0.118*	0.118*	0.118*	0.118*
Eora		0.039	0.031	0.026	0.024	0.023	0.023	0.039	0.031	0.026	0.024	0.023	0.023
	n=34	0.112*	0.113*	0.117*	0.117*	0.118*	0.119*	0.111*	0.112*	0.116*	0.116*	0.118*	0.118*
		0.032	0.028	0.024	0.023	0.022	0.022	0.032	0.028	0.024	0.023	0.022	0.022
	n=22	0.107*	0.110*	0.111*	0.112*	0.112*	0.112*	0.107*	0.110*	0.111*	0.111*	0.112*	0.112*
		0.030	0.026	0.022	0.019	0.019	0.019	0.030	0.026	0.022	0.019	0.019	0.019
Germany	n=67	0.102*	0.107*	0.108*	0.108*	0.108*	0.108*	0.103*	0.107*	0.109*	0.108*	0.108*	0.108*
DESTATIS		0.032	0.030	0.027	0.025	0.024	0.024	0.033	0.031	0.029	0.026	0.025	0.024
	n=34	0.100*	0.101*	0.104*	0.105*	0.105*	0.106*	0.100*	0.101*	0.104*	0.105*	0.105*	0.106*
		0.029	0.024	0.023	0.021	0.019	0.019	0.029	0.024	0.022	0.021	0.019	0.019
	n=22	0.102*	0.104*	0.107*	0.107*	0.109*	0.109*	0.102*	0.104*	0.108*	0.107*	0.109*	0.109*
		0.028	0.023	0.021	0.019	0.017	0.016	0.028	0.023	0.021	0.019	0.017	0.016

MC simulation results for varying size n - continued

Appendix B. Supplementary Material for Chapter 3

MPS	SNA
1. Differences in underlying concepts and definitions	
Economic production is restricted to the production of material goods and material services	Economic production includes all activities for producing goods and services, except for domestic services that are produced by households for their own use
Primary income is restricted to income received by enterprises and the population for their participation in the production of material goods and material services; income from property is not included in this flow	Primary income is defined as incomes that accrue to institutional units for their participation in the production in all industries of the economy or the ownership of assets that are used for production
The redistribution of income is defined as the payment of conventional transfers (taxes, insurance premiums, social benefits, etc) plus payments for non-material services and wages in the non-material sphere, plus income from property	The redistribution of income is defined to include transfers (both in cash and in kind), i.e. transactions in which one institutional unit provides a good, service, or asset to another unit without receiving any good, service, or asset from the latter
2. Differences in the structure of the two systems of national accounting	
A system of tables and balances that are used for recording transactions with material goods and material services, material balance, as well as the flows of income from these activities. Financial balance: table on stocks of tangible fixed assets is also a part of the MPS	A system of accounts (current, accumulation, and balance sheet), the compilation of which makes it possible to analyze all major phases of the economic process: production, generation of income, distribution, redistribution and use of income, accumulation, and stocks of asset
3. Differences in the content of indicators and classifications	
Net material product is defined as the sum of value added that originated in the material sphere in the territory of the given country	Gross domestic product is defined as the sum of gross value added that is produced by the resident-producers in all industries of the economy of the given country
The NMP is classified by branches of the material sphere	The GDP is classified by industries and institutional sectors
The disposition of the NMP includes final uses of material goods and material services on final consumption, accumulation, losses, and net exports	The disposition of the GDP includes final uses of all goods and services on final consumption, gross capital formation, and net exports
The NMP can be also regarded as the sum of primary income that is payable to participants in material production (population and enterprises)	The GDP can be also regarded as the sum of compensation of employees, gross operating surplus, and net taxes on production and imports
National wealth is defined to include the stock of fixed assets and inventories on a certain date	National wealth is defined to include the stock of all assets (non-financial and financial) less the stock of liabilities on the same date
The major classifications in the MPS is classification by branches of the national economy (CBNE) and by social type of unit (state, cooperative, private, and so forth)	In the SNA, in addition to the ISIC classification by the institutional sectors of economy, as well as such classifications as the Classification of Individual Consumption by Purpose (COICOP) and the Classification of the Functions of Government (COFOG), are also important. The ISIC differs considerably from the CBNE

* As covered in Ivanov (2009).

Table B.1: The main differences between the MPS and the SNA

Code	OKONh Industry
10000	Industry
11100	Electric power industry
11200	Fuel industry
11210	Oil extracting industry
11220	Oil refining industry
11230	Natural gas industry
11300	Coal industry
11410	Shale industry
11610	Peat industry
12100	Ferrous metallurgy
12110	Extraction and concentration of ferrous metal ores
12120	Extraction and concentration of ferrous nonmetallic feed
12160	Chemical-recovery coal carbonization
12170	Refractory materials (flux) production
12200	Non-ferrous metallurgy
13000	Chemical and petrochemical industry
13100	Chemical industry
13120	Chemical fibers and threads
13150	Paint and varnish industry
13170	Synthetic dyes
13300	Petrochemical industry
13320	Products of organic synthesis
13360	Rubber and asbestos industry
14000	Machine-building and metal working
14100	Machine building
14130	Machine-building for metallurgy
14140	Machine-building for mining and ore mining
14150	Materials handling machine building
14160	Railway machine-building
14170	Electrical engineering industry
14172	Cable industry
14173	Electric-bulb industry
14175	Accumulator and elemental industry
14200	Machine-tool and tool-making industry
14320	Instrument-making industry
14330	Computer and office equipment
14340	Motor-car construction
14342	Motorcycles, bikes, and spare parts for them
14350	Bearings
14400	Tractor and farm-machine building
14510	Machine-building for road works and construction
14540	Equipment for municipal economy and consumer services
14610	Manufacturing equipment for light industry
14640	Manufacturing equipment for printing industry
14650	Home appliances and equipment
14710	Sanitary and hygiene equipment; gas equipment and articles
14780	Machine-building, other
14830	Metal structures and articles
14900	Machine and equipment maintenance
15000	Logging, woodworking and pulp-and-paper industry
15270	Furniture industry
15300	Pulp and paper
15400	Resin industry
16100	Building materials industry
16110	Cement
16120	Asbestos-cement goods
16130	Soft roofing and waterproofing materials
16140	Prefabricated concrete and ferroconcrete items (excl. walling)
16150	Walling
16160	Building ceramics
16170	Polymeric building materials
16180	Non-metallic building materials
16500	Glass, porcelain and earthenware industry
17000	Light industry
17100	Textile industry
17150	Knitting industry
17200	Clothing industry
17370	Shoe industry, excl. repair
17900	Light industry, other
18000	Food industry
18111	Sugar industry
18121	Oil-and-fat industry
18122	Soap and fat-base detergents
18131	Perfume and cosmetic production
18143	Wine industry
18150	Fruit and vegetable processing industry
18180	Tobacco industry
18210	Meat industry
18220	Butter, cheese and milk industry
18300	Fishing industry
18411	Confectionary industry
19100	Microbiological industry
19200	Flour-and-cereals industry
19210	Flour industry
19220	Mixed fodder industry
19310	Chemical and pharmaceutical industry
19320	Medical equipment industry
19330	Glass, porcelain and plastic medical items
19400	Printing industry
19700	Industry, other
20000	Agriculture
21000	Farm production
21100	Crop raising
21200	Cattle production
22000	Farm services
30000	Forestry
50000	Transport and communications
51111	Land Rail-Road transport (except Trams)
51112	Tram transport
51113	Subway transport
51121	Automobile fleet
51122	Trolley transport
51123	Road facilities
51130	Main pipeline transport
51210	Sea transport
51220	Inland water transport
51300	Air transport
52000	Communications
60000	Construction
70000	Trade and Catering
71300	Catering
80000	Procurement and distribution
81000	Procurements
82000	Information services
83000	Real estate operations
84000	Other business activities
85000	Geology and exploration works; geodesy and hydrometeorology
87000	Production of goods, other
87100	Publishing
87400	Private security
90000	Housing and public utilities
90100	Housing
90200	Public utilities
90300	Non-production types of every-day services
91000	Health care physical culture and social security
92000	Education
93000	Culture and art
95000	Science and related services
96000	Finances, credit, insurance, pension security
96100	Banking
96200	Insurance
96300	Provision of pensions
97000	Administration
98000	Public amalgamations

Table B.2: The detailed OKONh industry classification

Abbreviation	Industry name
elec	Electric power industry
oil_exc	Oil extracting industry
oil_proc	Oil processing industry
gas	Natural gas industry
coal	Coal industry
oil_shales	Other fuel industries
fer_met	Ferrous metallurgy industry
non_fer_met	Non-ferrous metallurgy industry
chem	Chemical and petrochemical industry
machin	Mechanical engineering and metal-working industry
wood	Timber, woodworking, pulp and paper industry
build_mat	Construction materials industry
textiles	Light industry
food	Food industry
manuf_goods	Other manufacturing industries
constr	Construction industry
agr_prod	Agriculture and forestry industry
trans	Transportation industry
comm_serv	Post, communication services industry
trade_serv	Trade and public catering industry
non_manuf_serv	Other goods-producing industries
hous_serv	Communal and (market) consumer services industries
health_educ_serv	Public health, sports, social security, education and culture industries
r_d_serv	Science and science servicing, geology industries
fin_serv	Financial services industry

Table B.3: Industry Abbreviation

Industry	1980 Mult	1980 Rank	1981 Mult	1981 Rank	1982 Mult	1982 Rank	1983 Mult	1983 Rank	1984 Mult	1984 Rank	1985 Mult	1985 Rank	1986 Mult	1986 Rank	1987 Mult	1987 Rank	1988 Mult	1988 Rank	1989 Mult	1989 Rank	1990 Mult	1990 Rank	1991 Mult	1991 Rank
elec	0.18	22	0.19	22	0.18	22	0.18	22	0.18	22	0.18	22	0.18	22	0.17	22	0.17	22	0.17	22	0.16	22	0.15	22
oil_exc	0.82	10	0.81	10	0.84	9	0.85	9	0.85	9	0.86	9	0.89	9	0.92	9	0.93	9	0.92	8	0.92	9	0.91	9
oil_proc	0.46	14	0.44	14	0.54	13	0.51	13	0.53	13	0.44	14	0.44	14	0.58	13	0.59	13	0.65	13	0.62	13	0.54	15
gas	0.66	11	0.64	11	0.68	11	0.71	11	0.69	11	0.69	11	0.70	11	0.79	10	0.81	10	0.89	10	0.91	10	0.73	11
coal	0.20	20	0.21	20	0.28	17	0.29	16	0.30	16	0.33	16	0.34	17	0.54	14	0.59	14	0.59	14	0.48	17	0.40	18
oil_shales	0.02	24	0.02	24	0.01	24	0.01	24	0.01	24	0.01	24	0.01	25	0.11	24	0.00	25	0.00	25	0.00	25	0.02	25
fer_met	0.55	12	0.57	12	0.58	12	0.55	12	0.57	12	0.56	12	0.55	12	0.65	12	0.63	12	0.68	12	0.66	12	0.57	12
non_fer_met	0.19	21	0.20	21	0.22	21	0.23	20	0.24	20	0.26	20	0.30	18	0.37	17	0.39	18	0.43	17	0.42	19	0.37	20
chem	0.23	18	0.24	18	0.23	20	0.23	21	0.22	21	0.23	21	0.23	21	0.26	21	0.27	21	0.26	21	0.26	21	0.22	21
machin	1.84	1	1.77	1	1.71	1	1.65	1	1.60	2	1.56	2	1.51	4	1.46	4	1.51	4	1.50	4	1.53	3	1.49	4
wood	0.33	15	0.34	15	0.35	15	0.34	15	0.34	15	0.36	15	0.37	15	0.38	16	0.39	17	0.39	20	0.38	20	0.38	19
build_mat	0.10	23	0.09	23	0.11	23	0.10	23	0.10	23	0.11	23	0.12	23	0.13	23	0.13	23	0.14	23	0.15	23	0.11	23
textiles	1.27	6	1.23	7	1.06	8	1.04	8	1.15	7	1.18	7	1.16	7	1.14	7	1.15	7	1.15	6	1.18	6	1.19	6
food	1.47	5	1.47	5	1.48	5	1.50	4	1.51	4	1.52	4	1.57	2	1.49	3	1.55	3	1.51	3	1.48	4	1.53	3
manuf_goods	1.18	7	1.30	6	1.13	6	1.18	6	1.24	6	1.19	6	1.27	6	1.38	6	1.29	6	0.91	9	1.15	7	1.10	7
constr	1.51	3	1.51	4	1.48	4	1.46	5	1.47	5	1.46	5	1.42	5	1.44	5	1.42	5	1.39	5	1.38	5	1.44	5
agr_prod	0.84	9	0.82	9	0.83	10	0.78	10	0.76	10	0.75	10	0.71	10	0.67	11	0.65	11	0.72	11	0.74	11	0.80	10
trans	0.48	13	0.48	13	0.48	14	0.48	14	0.49	14	0.50	13	0.49	13	0.45	15	0.47	15	0.49	15	0.54	14	0.56	13
comm_serv	0.21	19	0.23	19	0.24	19	0.27	18	0.30	17	0.32	17	0.35	16	0.36	18	0.40	16	0.45	16	0.52	15	0.55	14
trade_serv	1.10	8	1.09	8	1.11	7	1.09	7	1.07	8	1.06	8	1.09	8	1.08	8	1.08	8	1.06	7	1.03	8	1.02	8
non_manuf_serv	0.00	25	0.00	25	0.01	25	0.00	25	0.01	25	0.01	25	0.01	24	0.01	25	0.02	24	0.02	24	0.03	24	0.04	24
hous_serv	0.23	17	0.25	17	0.26	18	0.26	19	0.28	19	0.29	19	0.30	19	0.33	19	0.38	19	0.43	18	0.48	16	0.54	16
health_educ_serv	1.56	2	1.56	2	1.55	3	1.54	3	1.54	3	1.53	3	1.54	3	1.55	2	1.58	1	1.58	1	1.62	1	1.64	1
r_d_serv	0.29	16	0.30	16	0.30	16	0.28	17	0.29	18	0.29	18	0.30	20	0.32	20	0.37	20	0.39	19	0.44	18	0.46	17
fin_serv	1.51	4	1.54	3	1.56	2	1.62	2	1.62	1	1.65	1	1.64	1	1.60	1	1.57	2	1.57	2	1.56	2	1.60	2

Industry	1992 Mult	1992 Rank	1993 Mult	1993 Rank	1994 Mult	1994 Rank	1995 Mult	1995 Rank	1996 Mult	1996 Rank	1997 Mult	1997 Rank	1998 Mult	1998 Rank	1999 Mult	1999 Rank	2000 Mult	2000 Rank	2001 Mult	2001 Rank	2002 Mult	2002 Rank	2003 Mult	2003 Rank
elec	0.15	22	0.15	22	0.17	22	0.17	22	0.17	23	0.17	24	0.18	24	0.19	24	0.18	25	0.21	24	0.22	24	0.24	24
oil_exc	0.89	9	0.84	9	0.88	9	0.88	11	0.87	14	0.84	13	0.89	11	0.88	12	0.89	10	0.91	9	0.93	9	0.96	8
oil_proc	0.55	16	0.67	14	0.85	11	0.83	14	0.86	15	0.84	14	0.80	14	0.75	17	0.79	16	0.73	17	0.77	15	0.75	17
gas	0.82	11	0.76	12	0.83	13	0.87	12	0.88	13	0.88	12	0.89	12	0.89	11	0.83	14	0.71	18	0.74	16	0.75	16
coal	0.39	19	0.39	20	0.40	21	0.48	21	0.44	21	0.40	21	0.44	21	0.48	21	0.56	20	0.63	20	0.64	20	0.73	18
oil_shales	0.02	25	0.02	25	0.03	25	0.05	25	0.06	25	0.09	25	0.12	25	0.17	25	0.23	23	0.26	23	0.25	23	0.27	23
fer_met	0.64	13	0.92	8	1.15	7	1.14	7	1.17	7	1.10	7	1.19	6	0.98	8	0.86	11	0.82	13	0.86	12	0.91	10
non_fer_met	0.51	17	0.66	17	0.86	10	0.94	9	0.96	9	0.97	9	0.98	9	0.97	9	0.98	8	0.90	11	0.87	11	0.86	11
chem	0.28	21	0.38	21	0.53	19	0.62	18	0.68	18	0.70	17	0.78	15	0.80	14	0.85	12	0.91	10	0.89	10	0.86	12
machin	1.46	5	1.36	5	1.27	5	1.33	4	1.26	5	1.24	5	1.19	5	1.15	5	1.14	7	1.13	7	1.15	7	1.10	7
wood	0.38	20	0.44	19	0.54	18	0.61	19	0.57	19	0.62	19	0.66	19	0.77	16	0.81	15	0.76	15	0.79	14	0.77	14
build_mat	0.08	23	0.13	23	0.15	23	0.17	23	0.21	22	0.21	23	0.23	23	0.22	23	0.20	24	0.12	25	0.07	25	0.07	25
textiles	1.21	6	1.19	6	1.19	6	1.20	6	1.21	6	1.21	6	1.17	7	1.15	6	1.19	5	1.20	6	1.19	6	1.20	6
food	1.57	3	1.57	2	1.49	3	1.44	3	1.41	2	1.38	3	1.37	3	1.43	3	1.38	3	1.40	3	1.37	3	1.35	4
manuf_goods	0.95	8	0.79	11	0.82	14	0.78	15	0.91	11	0.82	15	0.77	16	0.79	15	0.75	17	0.77	14	0.69	19	0.55	20
constr	1.49	4	1.40	4	1.31	4	1.31	5	1.27	4	1.36	4	1.35	4	1.40	4	1.35	4	1.34	4	1.28	5	1.26	5
agr_prod	0.86	10	0.84	10	0.84	12	0.86	13	0.90	12	0.91	11	0.86	13	0.86	13	0.84	13	0.84	12	0.82	13	0.83	13
trans	0.61	14	0.66	16	0.68	17	0.70	17	0.71	17	0.69	18	0.67	18	0.66	19	0.69	19	0.70	19	0.73	17	0.75	15
comm_serv	0.59	15	0.66	15	0.70	16	0.74	16	0.79	16	0.72	16	0.73	17	0.72	18	0.75	18	0.74	16	0.72	18	0.68	19
trade_serv	1.01	7	0.98	7	0.95	8	0.94	8	0.97	8	0.94	10	0.94	10	0.94	10	0.93	9	0.94	8	0.94	8	0.96	9
non_manuf_serv	0.05	24	0.07	24	0.09	24	0.14	24	0.16	24	0.23	22	0.33	22	0.37	22	0.45	22	0.51	22	0.51	21	0.51	22
hous_serv	0.65	12	0.71	13	0.79	15	0.89	10	0.92	10	0.99	8	1.04	8	1.12	7	1.17	6	1.28	5	1.37	4	1.49	2
health_educ_serv	1.65	1	1.62	1	1.59	1	1.62	1	1.56	1	1.60	1	1.58	1	1.57	1	1.58	1	1.58	1	1.58	1	1.59	1
r_d_serv	0.42	18	0.44	18	0.45	20	0.51	20	0.51	20	0.55	20	0.54	20	0.52	20	0.51	21	0.51	21	0.51	22	0.53	21
fin_serv	1.58	2	1.52	3	1.50	2	1.47	2	1.41	3	1.46	2	1.45	2	1.47	2	1.49	2	1.50	2	1.48	2	1.45	3

Table B.4: Net output multipliers

	2004		2005		2006	
Industry	Mult	Rank	Mult	Rank	Mult	Rank
elec	0.23	23	0.25	23	0.26	23
oil_exc	1.00	8	0.99	8	0.97	9
oil_proc	0.75	15	0.75	17	0.76	16
gas	0.75	14	0.76	16	0.71	18
coal	0.74	16	0.82	14	0.80	14
oil_shales	0.18	24	0.14	24	0.05	25
fer_met	0.90	10	0.90	10	0.94	10
non_fer_met	0.84	13	0.83	13	0.84	13
chem	0.86	12	0.88	12	0.89	12
machin	1.09	7	1.08	7	1.10	7
wood	0.74	17	0.79	15	0.80	15
build_mat	0.14	25	0.11	25	0.12	24
textiles	1.18	6	1.19	6	1.21	6
food	1.29	4	1.30	4	1.29	4
manuf_goods	0.62	20	0.60	20	0.58	22
constr	1.25	5	1.23	5	1.23	5
agr_prod	0.89	11	0.89	11	0.89	11
trans	0.74	18	0.73	18	0.73	17
comm_serv	0.72	19	0.68	19	0.68	19
trade_serv	0.97	9	0.99	9	0.99	8
non_manuf_serv	0.48	22	0.55	21	0.59	20
hous_serv	1.48	2	1.47	2	1.40	2
health_educ_serv	1.57	1	1.56	1	1.56	1
r_d_serv	0.52	21	0.53	22	0.58	21
fin_serv	1.43	3	1.39	3	1.36	3

Net output multipliers - continued

Industry	1980 Mult	1980 Rank	1981 Mult	1981 Rank	1982 Mult	1982 Rank	1983 Mult	1983 Rank	1984 Mult	1984 Rank	1985 Mult	1985 Rank	1986 Mult	1986 Rank	1987 Mult	1987 Rank	1988 Mult	1988 Rank	1989 Mult	1989 Rank	1990 Mult	1990 Rank	1991 Mult	1991 Rank
elec	0.17	21	0.18	21	0.18	21	0.18	21	0.18	21	0.17	21	0.18	21	0.17	21	0.17	21	0.17	22	0.16	21	0.15	22
oil_exc	0.75	11	0.74	11	0.78	11	0.79	10	0.79	10	0.80	10	0.83	10	0.86	10	0.87	10	0.87	11	0.87	9	0.84	10
oil_proc	1.06	8	1.12	8	1.16	7	1.06	7	1.42	5	0.95	8	0.91	8	1.15	7	1.15	7	1.25	8	1.57	3	1.48	6
gas	0.59	12	0.57	12	0.60	12	0.63	12	0.62	12	0.62	12	0.63	12	0.71	11	0.73	11	0.81	12	0.82	11	0.66	13
coal	0.18	20	0.19	20	0.26	17	0.28	16	0.28	16	0.31	15	0.33	16	0.51	13	0.56	13	0.56	14	0.45	17	0.38	19
oil_shales	0.02	23	0.02	23	0.01	23	0.01	23	0.01	23	0.01	23	0.01	24	0.09	23	0.00	24	0.00	25	0.00	24	0.01	25
fer_met	1.08	7	1.15	7	1.02	8	0.92	9	0.91	9	0.89	9	0.86	9	0.95	9	0.92	9	0.95	10	0.86	10	0.69	12
non_fer_met	0.22	17	0.24	17	0.26	18	0.27	17	0.28	17	0.31	17	0.36	15	0.46	14	0.48	14	0.55	15	0.60	13	0.52	16
chem	0.30	15	0.32	15	0.28	15	0.28	15	0.27	19	0.27	19	0.27	20	0.30	19	0.30	20	0.28	21	0.29	20	0.23	21
machin	4.01	1	3.29	1	2.86	1	2.50	1	2.27	1	2.10	1	1.91	2	1.80	2	1.99	2	1.98	3	1.83	2	1.73	3
wood	0.37	14	0.38	14	0.37	14	0.36	14	0.37	14	0.39	14	0.40	14	0.40	16	0.42	16	0.41	18	0.39	19	0.38	20
build_mat	0.11	22	0.10	22	0.11	22	0.11	22	0.11	22	0.11	22	0.12	22	0.14	22	0.13	22	0.14	23	0.15	22	0.11	23
textiles	2.21	2	1.99	2	1.39	4	1.38	4	1.66	3	1.79	3	1.66	3	1.42	4	1.45	4	1.52	4	1.47	4	1.51	4
food	1.68	3	1.65	3	1.69	2	1.88	2	1.90	2	1.97	2	2.65	1	2.52	1	2.94	1	2.33	2	2.12	1	2.05	2
manuf_goods	-0.65	25	-0.68	25	-0.90	25	-1.28	25	-1.50	25	-1.31	25	-1.34	25	-1.34	25	-0.83	25	2.61	1	-6.44	25	17.20	1
constr	1.32	6	1.33	6	1.31	6	1.30	6	1.32	7	1.32	6	1.28	6	1.36	6	1.33	6	1.31	7	1.27	7	1.34	8
agr_prod	0.78	10	0.79	10	0.79	10	0.73	11	0.71	11	0.71	11	0.66	11	0.63	12	0.61	12	0.69	13	0.71	12	0.78	11
trans	0.43	13	0.43	13	0.43	13	0.43	13	0.44	13	0.45	13	0.44	13	0.41	15	0.43	15	0.45	16	0.50	14	0.52	15
comm_serv	0.21	18	0.22	18	0.24	19	0.26	18	0.29	15	0.31	16	0.33	17	0.34	17	0.38	17	0.43	17	0.50	15	0.52	14
trade_serv	0.99	9	0.99	9	1.01	9	1.00	8	0.98	8	0.97	7	1.00	7	0.99	8	0.99	8	0.97	9	0.94	8	0.93	9
non_manuf_serv	0.00	24	0.00	24	0.00	24	0.00	24	0.01	24	0.01	24	0.01	23	0.01	24	0.01	23	0.02	24	0.02	23	0.03	24
hous_serv	0.21	19	0.22	19	0.23	20	0.23	20	0.25	20	0.27	20	0.28	18	0.30	18	0.36	18	0.40	19	0.45	16	0.50	17
health_educ_serv	1.38	5	1.38	5	1.37	5	1.36	5	1.36	6	1.36	5	1.36	5	1.37	5	1.40	5	1.42	6	1.46	6	1.47	7
r_d_serv	0.27	16	0.27	16	0.27	16	0.26	19	0.27	18	0.27	18	0.28	19	0.29	20	0.34	19	0.36	20	0.40	18	0.42	18
fin_serv	1.39	4	1.41	4	1.46	3	1.54	3	1.54	4	1.59	4	1.57	4	1.51	3	1.47	3	1.49	5	1.47	5	1.50	5

Industry	1992 Mult	1992 Rank	1993 Mult	1993 Rank	1994 Mult	1994 Rank	1995 Mult	1995 Rank	1996 Mult	1996 Rank	1997 Mult	1997 Rank	1998 Mult	1998 Rank	1999 Mult	1999 Rank	2000 Mult	2000 Rank	2001 Mult	2001 Rank	2002 Mult	2002 Rank	2003 Mult	2003 Rank
elec	0.15	22	0.15	22	0.17	21	0.17	22	0.17	23	0.18	24	0.18	24	0.19	24	0.19	25	0.22	24	0.23	24	0.24	24
oil_exc	0.82	12	0.78	13	0.81	12	0.82	13	0.80	16	0.78	16	0.82	16	0.81	17	0.83	15	0.84	14	0.86	13	0.89	12
oil_proc	2.39	2	11.92	1	-6.60	25	-13.32	25	2.13	1	1.93	2	1.71	2	1.63	2	1.78	2	1.69	2	1.83	1	1.83	1
gas	0.74	13	0.70	14	0.78	13	0.81	14	0.83	15	0.83	15	0.83	15	0.83	15	0.78	17	0.66	19	0.70	18	0.71	18
coal	0.38	20	0.38	21	0.39	20	0.48	20	0.44	21	0.40	21	0.43	21	0.47	21	0.55	20	0.62	20	0.62	20	0.71	17
oil_shales	0.02	25	0.02	25	0.02	24	0.04	24	0.06	25	0.08	25	0.12	25	0.16	25	0.21	24	0.24	23	0.23	23	0.24	23
fer_met	0.83	11	1.34	8	1.56	2	1.38	4	1.40	4	1.30	7	1.37	5	1.11	8	0.97	10	0.91	11	0.95	10	1.00	9
non_fer_met	0.65	14	0.79	12	1.03	9	1.11	9	1.10	10	1.08	10	1.07	9	1.04	10	1.06	9	0.98	10	0.95	11	0.94	11
chem	0.32	21	0.44	19	0.63	17	0.71	15	0.84	14	0.83	14	0.90	12	0.89	12	0.96	11	1.01	9	1.00	9	0.96	10
machin	1.64	4	1.46	5	1.33	6	1.39	3	1.37	5	1.35	6	1.33	7	1.28	6	1.26	7	1.25	8	1.26	7	1.20	7
wood	0.39	18	0.46	18	0.58	18	0.65	18	0.62	19	0.67	19	0.71	17	0.82	16	0.86	13	0.80	16	0.83	14	0.79	15
build_mat	0.08	23	0.13	23	0.16	22	0.18	21	0.25	22	0.24	22	0.26	23	0.24	23	0.22	23	0.13	25	0.08	25	0.07	25
textiles	1.44	7	1.44	6	1.32	7	1.32	6	1.20	8	1.22	8	1.20	8	1.21	7	1.40	5	1.43	5	1.44	5	1.47	6
food	2.03	3	2.03	2	1.89	1	1.95	1	1.95	2	1.97	1	1.91	1	2.04	1	1.88	1	1.88	1	1.79	2	1.71	2
manuf_goods	3.14	1	1.94	3	1.48	3	1.17	8	1.34	6	1.17	9	0.94	11	0.97	11	0.85	14	0.85	13	0.73	16	0.57	20
constr	1.40	8	1.30	9	1.19	8	1.21	7	1.19	9	1.38	5	1.37	6	1.42	5	1.33	6	1.30	6	1.23	8	1.20	8
agr_prod	0.87	10	0.83	11	0.82	11	0.85	11	0.87	13	0.88	12	0.84	14	0.83	14	0.81	16	0.81	15	0.79	15	0.80	14
trans	0.57	16	0.62	17	0.66	16	0.68	17	0.70	18	0.68	17	0.66	19	0.64	19	0.67	19	0.68	18	0.72	17	0.75	16
comm_serv	0.56	17	0.63	16	0.67	15	0.71	16	0.75	17	0.67	18	0.68	18	0.68	18	0.71	18	0.70	17	0.69	19	0.65	19
trade_serv	0.91	9	0.89	10	0.87	10	0.87	10	0.90	11	0.87	13	0.87	13	0.87	13	0.87	12	0.87	12	0.88	12	0.89	13
non_manuf_serv	0.04	24	0.06	24	0.08	23	0.13	23	0.15	24	0.21	23	0.31	22	0.34	22	0.41	22	0.47	22	0.47	22	0.47	22
hous_serv	0.60	15	0.67	15	0.76	14	0.84	12	0.88	12	0.94	11	0.99	10	1.07	9	1.14	8	1.27	7	1.39	6	1.55	4
health_educ_serv	1.47	5	1.48	4	1.47	4	1.50	2	1.46	3	1.53	3	1.50	3	1.48	3	1.50	4	1.49	4	1.50	4	1.52	5
r_d_serv	0.39	19	0.42	20	0.44	19	0.50	19	0.52	20	0.58	20	0.56	20	0.53	20	0.53	21	0.52	21	0.51	21	0.53	21
fin_serv	1.47	6	1.43	7	1.43	5	1.38	5	1.33	7	1.47	4	1.45	4	1.47	4	1.52	3	1.55	3	1.58	3	1.62	3

Table B.5: Net value added multipliers

	2004		2005		2006	
Industry	Mult	Rank	Mult	Rank	Mult	Rank
elec	0.23	23	0.26	23	0.26	23
oil_exc	0.93	11	0.92	12	0.90	13
oil_proc	1.69	1	1.71	1	1.74	1
gas	0.71	18	0.71	18	0.67	18
coal	0.72	17	0.80	16	0.77	16
oil_shales	0.17	24	0.12	24	0.04	25
fer_met	0.99	9	0.99	9	1.03	9
non_fer_met	0.92	12	0.91	13	0.91	12
chem	0.95	10	0.97	10	0.98	10
machin	1.19	8	1.17	7	1.19	7
wood	0.77	15	0.81	15	0.82	15
build_mat	0.14	25	0.11	25	0.12	24
textiles	1.44	6	1.51	5	1.62	3
food	1.57	3	1.56	4	1.53	5
manuf_goods	0.63	20	0.60	20	0.58	20
constr	1.19	7	1.16	8	1.16	8
agr_prod	0.85	14	0.85	14	0.85	14
trans	0.73	16	0.72	17	0.72	17
comm_serv	0.69	19	0.65	19	0.65	19
trade_serv	0.91	13	0.92	11	0.92	11
non_manuf_serv	0.45	22	0.51	22	0.55	22
hous_serv	1.54	4	1.56	3	1.53	4
health_educ_serv	1.50	5	1.51	6	1.52	6
r_d_serv	0.52	21	0.53	21	0.57	21
fin_serv	1.58	2	1.60	2	1.64	2

Net value added multipliers - continued

Industry	1980 Type_1	Rank	Induced	Rank	Type_2	Rank	1981 Type_1	Rank	Induced	Rank	Type_2	Rank	1982 Type_1	Rank	Induced	Rank	Type_2	Rank	1983 Type_1	Rank	Induced	Rank	Type_2	Rank
elec	1.81	16	0.80	22	2.61	23	1.80	16	0.81	22	2.61	23	1.88	15	0.81	21	2.69	23	1.85	14	0.76	21	2.61	23
oil_exc	1.70	19	0.61	24	2.31	24	1.70	19	0.64	24	2.34	24	1.68	20	0.56	24	2.24	24	1.66	19	0.52	24	2.18	24
oil_proc	2.31	7	0.77	23	3.08	19	2.34	6	0.80	23	3.14	17	2.28	7	0.77	23	3.05	19	2.24	7	0.71	23	2.95	17
gas	1.60	22	0.48	25	2.08	25	1.58	23	0.46	25	2.04	25	1.54	23	0.40	25	1.94	25	1.51	23	0.36	25	1.87	25
coal	1.65	20	1.32	13	2.97	21	1.65	20	1.39	13	3.03	20	1.72	17	1.29	12	3.01	20	1.72	17	1.16	13	2.88	19
oil_shales	1.59	23	2.01	5	3.60	11	1.59	22	1.95	5	3.54	12	1.42	25	1.69	8	3.10	16	1.39	25	1.52	8	2.91	18
fer_met	2.56	4	1.18	14	3.75	9	2.55	3	1.19	14	3.74	8	2.49	3	1.10	15	3.59	7	2.43	3	0.97	15	3.40	8
non_fer_met	2.49	5	0.95	20	3.44	13	2.46	5	0.95	19	3.41	13	2.51	2	0.89	19	3.40	10	2.46	2	0.72	22	3.18	13
chem	2.33	6	1.01	18	3.34	14	2.30	7	1.00	18	3.30	14	2.24	8	0.92	17	3.16	14	2.21	8	0.88	18	3.09	15
machin	2.63	3	1.47	10	4.10	4	2.54	4	1.42	11	3.97	5	2.48	4	1.33	11	3.81	4	2.39	4	1.20	11	3.60	6
wood	2.17	9	1.40	12	3.57	12	2.16	10	1.41	12	3.57	11	2.10	9	1.26	13	3.36	12	2.07	9	1.20	12	3.26	11
build_mat	2.06	11	1.18	15	3.24	15	2.04	11	1.17	15	3.21	15	2.02	11	1.11	14	3.13	15	2.00	10	1.01	14	3.01	16
textiles	2.70	2	1.05	17	3.75	8	2.62	2	1.03	17	3.65	10	2.41	5	0.90	18	3.31	13	2.38	5	0.91	17	3.28	10
food	2.29	8	0.84	21	3.14	17	2.29	8	0.84	21	3.14	18	2.28	6	0.79	22	3.07	18	2.36	6	0.80	20	3.16	14
manuf_goods	3.68	1	1.87	7	5.55	1	3.68	1	1.91	6	5.59	1	3.49	1	1.71	7	5.20	1	3.34	1	1.56	7	4.89	1
constr	1.90	13	1.90	6	3.80	7	1.90	13	1.91	7	3.81	7	1.86	16	1.71	6	3.58	8	1.84	16	1.73	6	3.56	7
agr_prod	2.10	10	1.51	9	3.61	10	2.17	9	1.56	9	3.73	9	2.08	10	1.39	10	3.47	9	2.00	11	1.20	10	3.21	12
trans	1.72	17	1.46	11	3.18	16	1.70	17	1.46	10	3.16	16	1.69	19	1.41	9	3.10	17	1.65	20	1.23	9	2.88	20
comm_serv	1.98	12	2.35	3	4.33	3	1.91	12	2.28	3	4.19	3	1.95	12	2.21	3	4.16	2	1.86	13	2.00	4	3.86	3
trade_serv	1.53	25	1.59	8	3.12	18	1.54	24	1.60	8	3.14	19	1.58	22	1.81	5	3.38	11	1.55	22	1.74	5	3.29	9
non_manuf_serv	1.82	15	0.98	19	2.80	22	1.83	15	0.87	20	2.70	22	1.94	13	0.87	20	2.80	22	1.85	15	0.86	19	2.71	22
hous_serv	1.71	18	2.69	1	4.40	2	1.70	18	2.64	1	4.34	2	1.69	18	2.37	1	4.06	3	1.67	18	2.35	1	4.03	2
health_educ_serv	1.63	21	2.27	4	3.90	6	1.63	21	2.27	4	3.90	6	1.61	21	2.11	4	3.72	6	1.60	21	2.13	3	3.72	4
r_d_serv	1.55	24	2.37	2	3.92	5	1.53	25	2.46	2	3.99	4	1.50	24	2.26	2	3.75	5	1.45	24	2.23	2	3.68	5
fin_serv	1.90	14	1.16	16	3.06	20	1.89	14	1.15	16	3.03	21	1.88	14	1.05	16	2.93	21	1.88	12	0.94	16	2.82	21

Industry	1984 Type_1	Rank	Induced	Rank	Type_2	Rank	1985 Type_1	Rank	Induced	Rank	Type_2	Rank	1986 Type_1	Rank	Induced	Rank	Type_2	Rank	1987 Type_1	Rank	Induced	Rank	Type_2	Rank
elec	1.82	15	0.73	22	2.55	23	1.80	15	0.73	22	2.53	23	1.80	14	0.70	22	2.50	23	1.86	12	0.69	22	2.54	23
oil_exc	1.65	19	0.50	24	2.15	24	1.64	19	0.51	24	2.16	24	1.65	19	0.51	24	2.16	24	1.65	19	0.51	24	2.16	24
oil_proc	2.29	7	0.75	21	3.04	15	2.22	7	0.74	21	2.96	16	2.21	7	0.72	21	2.94	15	2.20	6	0.70	21	2.90	16
gas	1.48	23	0.33	25	1.81	25	1.46	23	0.31	25	1.77	25	1.46	23	0.30	25	1.76	25	1.47	23	0.30	25	1.77	25
coal	1.73	17	1.20	10	2.93	18	1.73	17	1.20	10	2.93	18	1.74	16	1.13	10	2.87	17	1.70	17	1.17	10	2.87	17
oil_shales	1.35	25	1.53	8	2.88	19	1.34	25	1.54	8	2.88	20	1.35	25	1.40	8	2.75	21	1.32	25	1.32	8	2.64	22
fer_met	2.40	4	0.95	16	3.35	9	2.39	4	0.94	16	3.33	9	2.35	5	0.88	18	3.22	11	2.28	4	0.87	18	3.15	9
non_fer_met	2.45	3	0.71	23	3.16	12	2.45	2	0.70	23	3.15	14	2.38	4	0.66	23	3.04	14	2.33	3	0.67	23	3.01	14
chem	2.16	8	0.85	19	3.01	16	2.14	8	0.82	20	2.96	17	2.09	8	0.75	20	2.84	18	2.08	8	0.75	20	2.83	18
machin	2.34	6	1.16	13	3.50	7	2.29	6	1.11	13	3.40	7	2.22	6	1.02	13	3.24	8	2.15	7	1.02	13	3.17	8
wood	2.04	9	1.18	12	3.22	11	2.05	9	1.17	12	3.22	11	2.04	9	1.11	12	3.15	12	1.99	9	1.10	12	3.09	11
build_mat	1.99	10	1.01	14	2.99	17	1.99	10	1.00	14	2.99	15	1.97	10	0.95	14	2.92	16	1.94	10	0.96	14	2.90	15
textiles	2.45	2	0.92	17	3.37	8	2.44	3	0.92	18	3.36	8	2.38	3	0.85	19	3.23	10	2.25	5	0.79	19	3.04	13
food	2.34	5	0.80	20	3.15	14	2.38	5	0.83	19	3.21	12	2.55	2	0.89	16	3.45	5	2.54	2	0.92	15	3.46	5
manuf_goods	3.27	1	1.54	7	4.80	1	3.29	1	1.55	7	4.84	1	3.23	1	1.47	7	4.70	1	3.14	1	1.46	7	4.60	1
constr	1.85	14	1.66	6	3.51	6	1.84	14	1.67	6	3.51	5	1.79	15	1.59	6	3.38	7	1.81	13	1.59	5	3.40	6
agr_prod	1.96	11	1.20	11	3.16	13	1.98	11	1.19	11	3.17	13	1.93	11	1.11	11	3.05	13	1.91	11	1.21	9	3.12	10
trans	1.63	20	1.23	9	2.86	20	1.62	20	1.27	9	2.89	19	1.60	20	1.21	9	2.81	19	1.62	20	1.17	11	2.79	19
comm_serv	1.81	16	1.96	4	3.77	3	1.77	16	2.14	2	3.90	3	1.72	17	2.02	2	3.74	3	1.74	16	1.92	3	3.66	4
trade_serv	1.54	22	1.75	5	3.29	10	1.53	22	1.72	5	3.25	10	1.55	22	1.69	5	3.24	9	1.52	22	1.56	6	3.08	12
non_manuf_serv	1.85	13	0.86	18	2.71	22	1.90	12	0.97	15	2.87	21	1.89	12	0.91	15	2.80	20	1.81	14	0.88	17	2.70	20
hous_serv	1.67	18	2.30	1	3.97	2	1.66	18	2.27	1	3.93	2	1.67	18	2.17	1	3.84	2	1.68	18	2.23	1	3.91	2
health_educ_serv	1.59	21	2.09	3	3.69	4	1.59	21	2.09	3	3.67	4	1.60	21	2.00	3	3.60	4	1.60	21	2.10	2	3.70	3
r_d_serv	1.46	24	2.20	2	3.66	5	1.44	24	2.05	4	3.49	6	1.42	24	1.99	4	3.41	6	1.46	24	1.90	4	3.36	7
fin_serv	1.87	12	0.97	15	2.84	21	1.88	13	0.93	17	2.81	22	1.85	13	0.88	17	2.73	22	1.80	15	0.89	16	2.69	21

Table B.6: Type I and Type II output multipliers

Industry	1988 Type_1	Rank	1988 Induced	Rank	1988 Type_2	Rank	1989 Type_1	Rank	1989 Induced	Rank	1989 Type_2	Rank	1990 Type_1	Rank	1990 Induced	Rank	1990 Type_2	Rank	1991 Type_1	Rank	1991 Induced	Rank	1991 Type_2	Rank
elec	1.83	12	0.72	22	2.56	22	1.80	13	0.74	22	2.53	23	1.80	13	0.79	21	2.60	23	1.84	13	0.91	16	2.75	21
oil_exc	1.67	18	0.58	24	2.25	24	1.66	19	0.58	24	2.24	24	1.65	20	0.64	24	2.29	24	1.65	21	0.68	23	2.32	23
oil_proc	2.21	6	0.73	21	2.94	15	2.18	6	0.74	20	2.93	16	2.26	4	0.85	17	3.10	12	2.27	4	0.71	22	2.98	18
gas	1.47	24	0.33	25	1.80	25	1.46	24	0.32	25	1.78	25	1.44	24	0.33	25	1.76	25	1.45	24	0.43	25	1.88	25
coal	1.69	17	1.21	10	2.90	17	1.67	18	1.28	8	2.95	15	1.67	18	1.35	9	3.03	15	1.72	17	0.55	24	2.27	24
oil_shales	1.37	25	1.48	8	2.85	19	1.37	25	1.50	7	2.87	17	1.32	25	1.48	7	2.80	20	1.31	25	2.12	3	3.43	7
fer_met	2.27	4	0.90	17	3.18	9	2.20	5	0.91	16	3.10	10	2.19	5	0.96	16	3.14	10	2.21	6	1.06	14	3.27	11
non_fer_met	2.30	3	0.69	23	2.99	14	2.26	4	0.69	23	2.95	14	2.53	2	0.77	22	3.30	8	2.69	2	0.90	17	3.59	6
chem	2.04	8	0.77	20	2.81	20	1.98	8	0.74	21	2.72	21	1.98	8	0.76	23	2.75	21	2.03	9	0.82	20	2.85	19
machin	2.19	7	1.12	12	3.31	8	2.14	7	1.11	11	3.25	8	2.11	7	1.19	11	3.30	7	2.18	7	1.19	9	3.37	9
wood	1.98	9	1.14	11	3.13	10	1.93	9	1.12	10	3.05	12	1.91	11	1.13	13	3.05	14	1.97	11	1.07	13	3.04	16
build_mat	1.89	11	1.02	14	2.91	16	1.86	11	1.01	15	2.87	18	1.87	12	1.05	15	2.91	18	1.92	12	1.16	11	3.08	15
textiles	2.26	5	0.82	19	3.08	12	2.26	3	0.84	18	3.10	9	2.18	6	0.83	19	3.01	17	2.26	5	0.78	21	3.04	17
food	2.61	2	0.94	16	3.55	6	2.48	2	0.85	17	3.33	7	2.44	3	0.84	18	3.27	9	2.44	3	0.82	19	3.27	12
manuf_goods	3.29	1	1.54	7	4.84	1	2.53	1	1.07	13	3.60	3	2.90	1	1.17	12	4.08	3	2.97	1	1.16	10	4.13	2
constr	1.79	14	1.71	5	3.50	7	1.76	14	1.67	5	3.43	6	1.73	15	1.75	5	3.48	6	1.81	14	1.62	7	3.43	8
agr_prod	1.92	10	1.12	13	3.04	13	1.91	10	1.10	12	3.02	13	1.93	9	1.09	14	3.02	16	2.06	8	1.08	12	3.14	13
trans	1.63	21	1.25	9	2.87	18	1.60	21	1.24	9	2.84	19	1.64	21	1.22	10	2.87	19	1.68	18	1.43	8	3.11	14
comm_serv	1.73	15	2.10	4	3.83	4	1.70	16	1.89	4	3.59	5	1.69	17	1.94	4	3.63	5	1.67	20	2.52	1	4.19	1
trade_serv	1.51	23	1.58	6	3.09	11	1.49	23	1.60	6	3.09	11	1.46	23	1.61	6	3.07	13	1.47	23	0.93	15	2.39	22
non_manuf_serv	1.67	19	0.85	18	2.52	23	1.73	15	0.81	19	2.54	22	1.92	10	0.81	20	2.72	22	1.98	10	0.85	18	2.84	20
hous_serv	1.70	16	2.47	1	4.18	2	1.69	17	2.51	1	4.19	1	1.71	16	2.51	1	4.22	1	1.73	16	2.08	4	3.81	4
health_educ_serv	1.63	20	2.28	2	3.92	3	1.63	20	2.06	3	3.69	2	1.67	19	2.13	3	3.79	4	1.68	19	2.16	2	3.84	3
r_d_serv	1.51	22	2.21	3	3.72	5	1.52	22	2.08	2	3.60	4	1.58	22	2.51	2	4.09	2	1.60	22	1.67	6	3.27	10
fin_serv	1.80	13	0.94	15	2.74	21	1.80	12	1.02	14	2.82	20	1.78	14	1.36	8	3.14	11	1.81	15	1.79	5	3.60	5

Industry	1992 Type_1	Rank	1992 Induced	Rank	1992 Type_2	Rank	1993 Type_1	Rank	1993 Induced	Rank	1993 Type_2	Rank	1994 Type_1	Rank	1994 Induced	Rank	1994 Type_2	Rank	1995 Type_1	Rank	1995 Induced	Rank	1995 Type_2	Rank
elec	1.82	14	0.66	22	2.49	22	1.77	13	0.85	24	2.62	23	1.75	13	0.82	23	2.57	22	1.77	13	1.06	20	2.83	21
oil_exc	1.65	21	0.72	21	2.37	23	1.58	21	1.18	20	2.76	22	1.50	22	1.06	22	2.57	23	1.49	21	0.69	24	2.18	23
oil_proc	2.37	4	0.65	23	3.02	18	2.40	2	1.28	16	3.68	12	2.45	1	1.66	11	4.11	4	2.41	1	0.91	22	3.31	10
gas	1.42	24	0.28	25	1.70	25	1.42	24	0.48	25	1.90	25	1.38	25	0.48	24	1.86	25	1.38	25	0.51	25	1.89	25
coal	1.80	16	1.59	9	3.39	14	1.76	14	2.12	5	3.88	6	1.74	14	1.92	6	3.66	6	1.75	14	1.77	6	3.52	6
oil_shales	1.41	25	1.52	11	2.93	20	1.37	25	2.69	3	4.06	3	1.39	23	1.84	7	3.23	15	1.40	23	1.13	16	2.53	22
fer_met	2.26	5	1.04	16	3.29	16	2.18	5	1.24	19	3.42	16	1.96	7	1.24	19	3.20	18	1.91	7	1.02	21	2.92	19
non_fer_met	2.55	2	0.95	19	3.50	12	2.33	4	1.24	18	3.57	15	2.23	4	1.65	12	3.88	5	2.18	4	1.29	14	3.47	7
chem	2.16	9	0.97	17	3.13	17	2.12	6	1.16	21	3.28	17	2.02	5	1.29	18	3.31	14	1.96	5	1.09	18	3.04	16
machin	2.16	8	1.40	12	3.56	10	1.98	9	1.68	11	3.65	14	1.79	11	1.80	9	3.59	10	1.79	12	1.46	10	3.25	12
wood	2.04	11	1.31	13	3.36	15	1.97	10	2.01	7	3.98	4	1.98	6	2.22	3	4.20	3	1.93	6	1.48	9	3.41	8
build_mat	1.95	12	1.56	10	3.51	11	1.87	12	2.10	6	3.97	5	1.86	9	1.76	10	3.62	9	1.87	9	1.31	13	3.18	13
textiles	2.21	7	1.23	15	3.44	13	2.00	8	1.67	12	3.68	13	1.69	15	1.97	5	3.66	7	1.58	20	1.38	12	2.95	18
food	2.51	3	1.27	14	3.78	6	2.39	3	1.46	15	3.85	8	2.23	3	1.24	20	3.47	11	2.28	3	1.10	17	3.39	9
manuf_goods	2.89	1	1.60	8	4.50	2	2.67	1	2.70	2	5.37	1	2.43	2	2.84	2	5.27	1	2.29	2	2.05	3	4.34	2
constr	1.88	13	1.70	6	3.57	9	1.76	15	1.47	14	3.22	18	1.64	18	1.55	14	3.20	17	1.65	17	1.61	8	3.27	11
agr_prod	2.23	6	1.66	7	3.89	4	2.08	7	1.68	10	3.76	10	1.89	8	1.31	17	3.20	16	1.89	8	1.07	19	2.96	17
trans	1.70	17	0.94	20	2.64	21	1.68	18	1.13	22	2.80	21	1.68	17	1.48	15	3.16	19	1.70	15	1.43	11	3.14	15
comm_serv	1.61	22	2.05	4	3.66	8	1.57	22	1.47	13	3.03	19	1.51	21	0.43	25	1.94	24	1.49	22	1.67	7	3.16	14
trade_serv	1.47	23	0.54	24	2.01	24	1.43	23	0.93	23	2.35	24	1.39	24	1.23	21	2.62	21	1.38	24	0.73	23	2.11	24
non_manuf_serv	2.06	10	0.95	18	3.02	19	1.95	11	1.84	9	3.79	9	1.81	10	1.58	13	3.38	13	1.82	10	3.18	1	5.00	1
hous_serv	1.70	18	2.15	3	3.85	5	1.68	19	1.26	17	2.94	20	1.63	19	1.33	16	2.96	20	1.63	19	1.21	15	2.84	20
health_educ_serv	1.69	20	2.43	2	4.11	3	1.66	20	2.22	4	3.88	7	1.62	20	1.82	8	3.44	12	1.65	18	2.05	4	3.70	4
r_d_serv	1.70	19	4.20	1	5.90	1	1.71	17	3.46	1	5.18	2	1.78	12	2.95	1	4.73	2	1.80	11	2.10	2	3.90	3
fin_serv	1.82	15	1.95	5	3.76	7	1.74	16	2.00	8	3.74	11	1.68	16	1.97	4	3.65	8	1.67	16	2.00	5	3.67	5

Type I and Type II output multipliers - continued

Industry	1996 Type_1	Rank	1996 Induced	Rank	1996 Type_2	Rank	1997 Type_1	Rank	1997 Induced	Rank	1997 Type_2	Rank	1998 Type_1	Rank	1998 Induced	Rank	1998 Type_2	Rank	1999 Type_1	Rank	1999 Induced	Rank	1999 Type_2	Rank
elec	1.71	12	0.89	20	2.60	21	1.72	12	0.88	20	2.60	20	1.72	12	0.89	19	2.61	19	1.74	12	1.07	13	2.81	17
oil_exc	1.46	20	0.77	22	2.23	22	1.46	20	0.81	22	2.27	22	1.44	20	0.80	21	2.24	22	1.46	21	0.69	22	2.14	22
oil_proc	2.12	3	0.76	23	2.87	15	2.12	2	0.80	23	2.93	16	2.09	2	0.74	23	2.84	17	2.13	2	0.65	23	2.78	19
gas	1.36	24	0.78	21	2.14	24	1.36	24	0.87	21	2.23	23	1.36	22	0.85	20	2.21	23	1.37	24	0.76	20	2.12	23
coal	1.69	13	1.92	3	3.61	3	1.68	15	1.94	3	3.62	4	1.67	15	1.83	5	3.50	4	1.69	15	2.05	4	3.74	4
oil_shales	1.38	23	1.48	10	2.86	16	1.38	23	1.70	6	3.08	15	1.27	25	1.83	4	3.10	13	1.39	22	1.78	6	3.17	8
fer_met	1.77	9	1.08	18	2.85	17	1.80	9	1.11	17	2.91	17	1.74	9	1.04	17	2.78	18	1.86	6	0.99	16	2.84	16
non_fer_met	2.02	4	1.49	9	3.51	6	2.01	4	1.39	13	3.39	7	1.98	4	1.08	16	3.06	14	1.98	4	0.82	19	2.80	18
chem	1.91	5	1.15	16	3.06	14	1.87	6	1.21	15	3.09	14	1.83	8	1.13	14	2.96	15	1.85	8	1.02	14	2.87	15
machin	1.73	10	1.45	11	3.18	10	1.74	10	1.56	11	3.29	11	1.73	10	1.57	7	3.30	6	1.82	10	1.32	11	3.14	9
wood	1.88	6	1.66	5	3.55	4	1.85	8	1.70	5	3.56	5	1.84	7	1.52	8	3.36	5	1.85	9	1.22	12	3.07	12
build_mat	1.87	7	1.35	13	3.22	9	1.86	7	1.46	12	3.33	9	1.85	6	1.40	11	3.25	9	1.89	5	1.40	9	3.29	6
textiles	1.45	21	1.27	14	2.71	19	1.43	21	1.08	18	2.51	21	1.43	21	1.11	15	2.54	20	1.51	20	1.00	15	2.51	20
food	2.15	1	1.09	17	3.24	8	2.17	1	1.15	16	3.32	10	2.16	1	0.99	18	3.15	10	2.18	1	0.85	18	3.04	13
manuf_goods	2.14	2	1.39	12	3.53	5	2.12	3	1.66	7	3.78	3	2.03	3	1.26	13	3.28	7	2.06	3	0.97	17	3.03	14
constr	1.60	15	1.52	8	3.12	13	1.72	14	1.63	8	3.34	8	1.70	14	1.45	10	3.15	11	1.76	11	1.37	10	3.13	11
agr_prod	1.71	11	0.92	19	2.63	20	1.72	13	0.96	19	2.68	19	1.73	11	0.75	22	2.47	21	1.73	13	0.69	21	2.43	21
trans	1.63	14	1.53	7	3.16	11	1.64	16	1.59	10	3.23	12	1.63	16	1.49	9	3.12	12	1.64	16	1.49	8	3.13	10
comm_serv	1.44	22	0.72	24	2.16	23	1.38	22	0.72	24	2.10	24	1.35	23	0.68	24	2.03	24	1.29	25	0.64	24	1.93	24
trade_serv	1.36	25	0.66	25	2.02	25	1.35	25	0.66	25	2.01	25	1.35	24	0.60	25	1.95	25	1.39	23	0.50	25	1.89	25
non_manuf_serv	1.49	19	1.64	6	3.13	12	1.56	19	1.60	9	3.16	13	1.61	17	1.66	6	3.27	8	1.64	18	1.95	5	3.58	5
hous_serv	1.59	16	1.22	15	2.81	18	1.61	18	1.30	14	2.90	18	1.59	19	1.34	12	2.93	16	1.64	17	1.54	7	3.18	7
health_educ_serv	1.58	18	2.09	2	3.67	2	1.63	17	1.91	4	3.54	6	1.61	18	2.01	3	3.62	3	1.60	19	2.20	3	3.80	3
r_d_serv	1.87	8	2.84	1	4.70	1	1.90	5	2.44	1	4.34	1	1.86	5	2.49	1	4.36	1	1.86	7	2.30	1	4.15	1
fin_serv	1.59	17	1.83	4	3.42	7	1.74	11	2.10	2	3.83	2	1.71	13	2.34	2	4.05	2	1.73	14	2.22	2	3.94	2

Industry	2000 Type_1	Rank	2000 Induced	Rank	2000 Type_2	Rank	2001 Type_1	Rank	2001 Induced	Rank	2001 Type_2	Rank	2002 Type_1	Rank	2002 Induced	Rank	2002 Type_2	Rank	2003 Type_1	Rank	2003 Induced	Rank	2003 Type_2	Rank
elec	1.72	12	1.13	13	2.85	18	1.75	12	1.18	15	2.93	18	1.74	12	1.10	19	2.85	19	1.75	11	1.10	18	2.85	19
oil_exc	1.46	21	0.67	23	2.13	22	1.46	21	0.90	21	2.36	23	1.45	21	0.87	21	2.33	23	1.46	21	0.85	22	2.31	24
oil_proc	2.13	2	0.63	24	2.76	19	2.16	1	0.74	23	2.90	19	2.15	1	0.76	24	2.91	18	2.17	1	0.78	24	2.94	18
gas	1.38	22	0.75	20	2.12	23	1.41	23	1.01	19	2.42	22	1.41	22	0.81	23	2.22	24	1.43	23	0.98	20	2.41	23
coal	1.66	15	1.98	5	3.64	5	1.65	16	1.79	6	3.45	6	1.62	17	1.69	7	3.31	8	1.61	17	1.64	8	3.24	10
oil_shales	1.36	24	2.32	2	3.69	4	1.41	22	3.85	1	5.26	1	1.40	23	3.91	1	5.32	1	1.44	22	2.46	4	3.89	4
fer_met	1.91	5	1.05	14	2.96	14	1.93	5	1.22	13	3.15	13	1.92	4	1.19	16	3.10	11	1.90	4	1.08	19	2.97	15
non_fer_met	1.92	4	1.00	18	2.93	16	2.05	3	1.19	14	3.24	10	2.10	2	1.21	14	3.31	9	2.10	2	1.24	15	3.35	8
chem	1.83	7	1.04	15	2.87	17	1.82	8	1.13	17	2.94	17	1.79	8	1.17	17	2.97	17	1.79	7	1.17	16	2.96	16
machin	1.83	9	1.43	9	3.25	9	1.84	7	1.57	8	3.41	7	1.79	9	1.63	8	3.42	6	1.78	9	1.65	7	3.43	7
wood	1.80	10	1.27	12	3.07	11	1.81	9	1.36	11	3.17	12	1.76	11	1.33	13	3.09	13	1.74	12	1.34	13	3.08	13
build_mat	1.86	6	1.41	10	3.27	8	1.85	6	1.50	10	3.35	8	1.82	6	1.59	9	3.41	7	1.78	8	1.50	11	3.29	9
textiles	1.49	20	1.03	16	2.52	20	1.50	20	1.06	18	2.56	20	1.49	20	1.13	18	2.62	21	1.50	20	1.14	17	2.64	21
food	2.14	1	0.89	19	3.02	12	2.11	2	0.91	20	3.02	16	2.07	3	0.94	20	3.01	15	2.03	3	0.96	21	2.99	14
manuf_goods	1.93	3	1.02	17	2.95	15	1.95	4	1.16	16	3.11	14	1.90	5	1.19	15	3.10	12	1.86	5	1.31	14	3.18	12
constr	1.70	14	1.31	11	3.01	13	1.69	15	1.34	12	3.03	15	1.63	16	1.37	12	3.00	16	1.59	18	1.35	12	2.95	17
agr_prod	1.70	13	0.74	21	2.44	21	1.69	14	0.77	22	2.45	21	1.66	14	0.84	22	2.50	22	1.64	15	0.84	23	2.48	22
trans	1.64	17	1.61	8	3.25	10	1.65	17	1.55	9	3.20	11	1.64	15	1.43	10	3.07	14	1.65	14	1.54	9	3.19	11
comm_serv	1.29	25	0.67	22	1.96	24	1.27	25	0.69	24	1.96	24	1.26	25	1.40	11	2.65	20	1.26	25	1.52	10	2.78	20
trade_serv	1.37	23	0.48	25	1.84	25	1.37	24	0.51	25	1.89	25	1.37	24	0.57	25	1.94	25	1.37	24	0.60	25	1.98	25
non_manuf_serv	1.57	19	1.95	6	3.52	6	1.56	19	1.79	7	3.35	9	1.53	19	1.74	6	3.27	10	1.54	19	1.99	5	3.53	6
hous_serv	1.66	16	1.73	7	3.39	7	1.71	13	1.83	5	3.55	5	1.74	13	1.85	5	3.59	5	1.78	10	1.96	6	3.74	5
health_educ_serv	1.61	18	2.25	4	3.86	3	1.60	18	2.35	2	3.95	4	1.60	18	2.61	3	4.21	3	1.61	16	2.67	1	4.28	3
r_d_serv	1.83	8	2.33	1	4.16	1	1.80	10	2.34	3	4.14	2	1.76	10	2.61	2	4.37	2	1.73	13	2.64	2	4.38	1
fin_serv	1.75	11	2.31	3	4.06	2	1.78	11	2.28	4	4.05	3	1.79	7	2.40	4	4.19	4	1.84	6	2.48	3	4.32	2

Type I and Type II output multipliers - continued

	2004						2005						2006					
Industry	Type_1	Rank	Induced	Rank	Type_2	Rank	Type_1	Rank	Induced	Rank	Type_2	Rank	Type_1	Rank	Induced	Rank	Type_2	Rank
elec	1.73	12	1.07	18	2.80	19	1.74	10	1.11	18	2.85	18	1.74	8	1.11	17	2.85	17
oil_exc	1.45	21	0.83	22	2.28	24	1.47	20	0.86	22	2.32	24	1.46	22	0.85	22	2.30	23
oil_proc	2.14	1	0.74	24	2.88	17	2.16	1	0.77	24	2.93	15	2.16	1	0.77	23	2.93	14
gas	1.42	23	0.95	20	2.37	23	1.44	23	0.98	20	2.42	22	1.44	23	0.99	20	2.43	22
coal	1.60	15	1.60	8	3.20	10	1.59	15	1.63	8	3.22	9	1.57	16	1.61	7	3.19	9
oil_shales	1.43	22	2.40	4	3.83	4	1.46	22	2.48	4	3.93	4	1.47	20	2.47	4	3.94	4
fer_met	1.87	4	1.04	19	2.91	14	1.87	4	1.07	19	2.94	14	1.85	4	1.06	19	2.91	15
non_fer_met	2.08	2	1.21	15	3.29	8	2.12	2	1.26	15	3.38	8	2.14	2	1.26	14	3.40	6
chem	1.77	8	1.14	16	2.91	15	1.75	9	1.15	16	2.90	16	1.73	9	1.14	16	2.87	16
machin	1.78	7	1.62	7	3.39	7	1.78	8	1.64	7	3.42	7	1.72	10	1.60	8	3.32	8
wood	1.73	11	1.31	13	3.04	13	1.70	13	1.32	13	3.01	13	1.67	12	1.28	12	2.95	13
build_mat	1.75	10	1.45	11	3.21	9	1.74	11	1.48	11	3.22	10	1.71	11	1.45	11	3.16	11
textiles	1.47	20	1.10	17	2.57	21	1.47	21	1.12	17	2.58	21	1.46	21	1.10	18	2.56	21
food	1.95	3	0.90	21	2.85	18	1.89	3	0.89	21	2.78	19	1.84	5	0.85	21	2.69	20
manuf_goods	1.83	5	1.27	14	3.09	12	1.80	6	1.28	14	3.07	12	1.77	7	1.25	15	3.02	12
constr	1.57	18	1.31	12	2.89	16	1.56	17	1.33	12	2.88	17	1.52	17	1.28	13	2.80	18
agr_prod	1.58	17	0.79	23	2.38	22	1.55	18	0.80	23	2.35	23	1.52	18	0.76	24	2.28	24
trans	1.64	14	1.50	9	3.14	11	1.66	14	1.54	9	3.19	11	1.64	14	1.54	9	3.18	10
comm_serv	1.26	25	1.49	10	2.75	20	1.26	25	1.49	10	2.75	20	1.25	25	1.50	10	2.75	19
trade_serv	1.37	24	0.58	25	1.95	25	1.37	24	0.60	25	1.97	25	1.37	24	0.59	25	1.96	25
non_manuf_serv	1.52	19	1.93	5	3.45	6	1.54	19	1.98	5	3.53	6	1.49	19	1.91	6	3.40	7
hous_serv	1.76	9	1.91	6	3.67	5	1.79	7	1.98	6	3.77	5	1.81	6	2.00	5	3.81	5
health_educ_serv	1.59	16	2.60	1	4.19	3	1.58	16	2.61	1	4.20	3	1.59	15	2.63	1	4.21	2
r_d_serv	1.72	13	2.57	2	4.29	1	1.71	12	2.55	2	4.26	2	1.67	13	2.50	3	4.17	3
fin_serv	1.82	6	2.41	3	4.23	2	1.87	5	2.52	3	4.39	1	1.89	3	2.57	2	4.45	1

Type I and Type II output multipliers - continued

Industry	1980 Output	Share	1981 Output	Share	1982 Output	Share	1983 Output	Share	1984 Output	Share	1985 Output	Share	1986 Output	Share	1987 Output	Share
elec	67,658.59	0.42%	73,758.97	0.45%	74,364.75	0.44%	77,295.40	0.43%	79,316.01	0.44%	79,648.72	0.43%	83,325.97	0.43%	83,903.36	0.42%
oil_exc	636,724.79	3.99%	640,454.75	3.92%	711,927.66	4.21%	739,223.54	4.15%	769,718.68	4.26%	712,689.31	3.86%	747,098.90	3.85%	806,274.73	4.00%
oil_proc	352,510.15	2.21%	341,686.58	2.09%	443,142.82	2.62%	439,624.03	2.47%	439,128.39	2.43%	364,228.53	1.97%	369,920.08	1.91%	496,447.17	2.47%
gas	28,621.74	0.18%	30,422.47	0.19%	38,049.65	0.22%	43,752.14	0.25%	49,137.01	0.27%	55,120.32	0.30%	59,975.71	0.31%	70,937.99	0.35%
coal	15,403.25	0.10%	16,113.88	0.10%	20,791.22	0.12%	21,681.22	0.12%	21,540.78	0.12%	25,093.50	0.14%	27,546.45	0.14%	41,258.10	0.20%
oil_shales	27.10	0.00%	22.80	0.00%	18.41	0.00%	19.64	0.00%	19.11	0.00%	21.64	0.00%	10.61	0.00%	169.18	0.00%
fer_met	241,127.92	1.51%	250,471.41	1.53%	252,382.05	1.49%	251,097.34	1.41%	263,448.39	1.46%	265,140.75	1.44%	274,214.39	1.41%	328,013.98	1.63%
non_fer_met	121,066.51	0.76%	127,278.93	0.78%	148,214.46	0.88%	157,150.00	0.88%	166,208.57	0.92%	187,553.90	1.02%	224,259.72	1.16%	281,829.54	1.40%
chem	91,575.59	0.57%	98,482.73	0.60%	96,738.44	0.57%	99,827.46	0.56%	104,010.56	0.58%	111,768.62	0.61%	119,754.98	0.62%	135,736.01	0.67%
machin	2,380,394.57	14.93%	2,398,351.98	14.69%	2,426,315.82	14.35%	2,439,899.10	13.70%	2,481,205.88	13.74%	2,584,299.12	14.01%	2,674,135.34	13.79%	2,679,839.00	13.31%
wood	121,061.16	0.76%	124,812.32	0.76%	138,830.05	0.82%	137,496.85	0.77%	140,603.54	0.78%	150,158.31	0.81%	161,933.89	0.84%	165,941.16	0.82%
build_mat	32,125.11	0.20%	29,569.69	0.18%	35,024.17	0.21%	34,470.33	0.19%	34,590.96	0.19%	35,684.35	0.19%	41,753.02	0.22%	44,954.77	0.22%
textiles	668,582.07	4.19%	658,064.43	4.03%	598,679.16	3.54%	586,431.60	3.29%	643,447.92	3.56%	660,180.68	3.58%	676,481.24	3.49%	662,430.72	3.29%
food	1,730,249.13	10.85%	1,760,100.79	10.78%	1,783,443.92	10.55%	1,862,540.58	10.46%	1,949,313.27	10.79%	1,891,387.04	10.25%	1,831,523.38	9.44%	1,743,631.68	8.66%
manuf_goods	169,245.23	1.06%	193,188.74	1.18%	172,468.54	1.02%	180,433.88	1.01%	192,471.38	1.07%	186,441.91	1.01%	211,496.16	1.09%	230,399.49	1.14%
constr	2,528,958.79	15.86%	2,579,185.06	15.80%	2,634,813.91	15.58%	2,687,293.10	15.09%	2,668,139.94	14.77%	2,669,189.36	14.47%	2,882,054.51	14.86%	3,079,837.12	15.30%
agr_prod	821,277.81	5.15%	782,559.81	4.79%	856,957.82	5.07%	882,087.98	4.95%	886,279.22	4.91%	871,388.16	4.72%	882,663.26	4.55%	829,285.69	4.12%
trans	531,457.43	3.33%	558,298.69	3.42%	574,490.28	3.40%	594,136.61	3.34%	618,114.42	3.42%	650,661.36	3.53%	689,122.00	3.55%	651,545.01	3.24%
comm_serv	22,929.62	0.14%	26,846.22	0.16%	30,438.83	0.18%	35,737.14	0.20%	41,462.51	0.23%	48,383.79	0.26%	57,382.21	0.30%	63,230.41	0.31%
trade_serv	2,380,734.43	14.93%	2,393,097.01	14.66%	2,392,537.34	14.15%	2,411,218.32	13.54%	2,349,978.57	13.01%	2,374,390.82	12.87%	2,524,133.38	13.02%	2,879,739.00	14.30%
non_manuf_serv	133.85	0.00%	193.13	0.00%	267.45	0.00%	250.11	0.00%	362.82	0.00%	493.92	0.00%	662.56	0.00%	660.15	0.00%
hous_serv	71,403.21	0.45%	76,389.70	0.47%	80,763.69	0.48%	81,734.17	0.46%	91,857.59	0.51%	97,764.59	0.53%	103,901.75	0.54%	115,860.92	0.58%
health_educ_serv	722,505.06	4.53%	736,012.38	4.51%	739,533.76	4.37%	744,774.60	4.18%	766,586.66	4.24%	777,271.15	4.21%	796,252.62	4.11%	827,208.01	4.11%
r_d_serv	94,938.22	0.60%	98,989.98	0.61%	105,180.02	0.62%	109,228.45	0.61%	115,761.80	0.64%	120,714.58	0.65%	132,407.05	0.68%	147,981.32	0.73%
fin_serv	2,111,068.84	13.24%	2,325,657.60	14.25%	2,554,042.50	15.10%	3,193,821.74	17.93%	3,189,231.59	17.66%	3,522,956.18	19.10%	3,817,736.03	19.69%	3,765,353.85	18.70%

Industry	1988 Output	Share	1989 Output	Share	1990 Output	Share	1991 Output	Share	1992 Output	Share	1993 Output	Share	1994 Output	Share	1995 Output	Share
elec	84,436.64	0.41%	86,282.16	0.41%	81,523.00	0.39%	77,283.00	0.39%	76,750.00	0.46%	71,810.00	0.48%	71,008.00	0.55%	69,737.00	0.57%
oil_exc	808,694.59	3.92%	796,482.81	3.79%	761,716.00	3.62%	672,598.00	3.40%	623,768.00	3.77%	535,798.00	3.59%	517,791.00	3.98%	494,489.00	4.07%
oil_proc	502,393.88	2.44%	556,469.86	2.65%	491,822.00	2.34%	423,579.00	2.14%	389,471.00	2.35%	410,910.00	2.75%	444,998.00	3.42%	440,797.00	3.63%
gas	78,269.61	0.38%	88,405.26	0.42%	94,837.00	0.45%	77,104.00	0.39%	83,868.00	0.51%	73,846.00	0.49%	76,471.00	0.59%	79,831.00	0.66%
coal	47,052.11	0.23%	45,083.86	0.21%	36,276.00	0.17%	27,158.00	0.14%	27,992.00	0.17%	25,399.00	0.17%	22,785.00	0.18%	27,223.00	0.22%
oil_shales	4.37	0.00%	4.71	0.00%	5.00	0.00%	23.00	0.00%	24.00	0.00%	25.00	0.00%	22.00	0.00%	37.00	0.00%
fer_met	330,036.74	1.60%	355,026.74	1.69%	350,893.00	1.67%	279,240.00	1.41%	263,041.00	1.59%	314,973.00	2.11%	328,884.00	2.53%	355,788.00	2.93%
non_fer_met	301,846.51	1.46%	344,282.57	1.64%	346,389.00	1.65%	272,571.00	1.38%	286,161.00	1.73%	314,865.00	2.11%	375,313.00	2.89%	421,334.00	3.47%
chem	150,002.82	0.73%	151,193.00	0.72%	155,991.00	0.74%	121,907.00	0.62%	119,316.00	0.72%	128,586.00	0.86%	137,574.00	1.06%	172,804.00	1.42%
machin	2,849,591.99	13.82%	2,852,997.75	13.58%	2,839,859.00	13.51%	2,491,095.00	12.61%	2,072,452.00	12.52%	1,622,903.00	10.88%	1,045,961.00	8.05%	991,234.00	8.17%
wood	178,616.69	0.87%	180,992.04	0.86%	175,780.00	0.84%	159,225.00	0.81%	135,645.00	0.82%	128,497.00	0.86%	109,163.00	0.84%	123,731.00	1.02%
build_mat	43,974.48	0.21%	49,540.39	0.24%	53,214.00	0.25%	38,675.00	0.20%	22,168.00	0.13%	30,077.00	0.20%	25,789.00	0.20%	25,700.00	0.21%
textiles	696,919.06	3.38%	707,338.74	3.37%	734,723.00	3.50%	674,459.00	3.41%	478,441.00	2.89%	363,979.00	2.44%	196,028.00	1.51%	138,620.00	1.14%
food	1,894,099.45	9.19%	1,974,221.54	9.40%	1,944,379.00	9.25%	1,832,338.00	9.27%	1,575,736.00	9.52%	1,434,350.00	9.61%	1,129,600.00	8.69%	1,004,160.00	8.27%
manuf_goods	226,565.40	1.10%	173,801.87	0.83%	214,459.00	1.02%	194,552.00	0.98%	145,746.00	0.88%	101,643.00	0.68%	89,737.00	0.69%	84,381.00	0.70%
constr	3,249,581.27	15.76%	3,292,790.40	15.67%	3,147,820.00	14.98%	2,889,762.00	14.63%	2,007,968.00	12.13%	1,731,656.00	11.61%	1,344,702.00	10.34%	1,211,396.00	9.98%
agr_prod	857,905.23	4.16%	920,350.45	4.38%	924,062.00	4.40%	953,859.00	4.83%	938,507.00	5.67%	879,795.00	5.90%	772,209.00	5.94%	742,526.00	6.12%
trans	706,797.51	3.43%	717,281.60	3.41%	784,683.00	3.73%	762,568.00	3.86%	711,117.00	4.30%	659,106.00	4.42%	583,193.00	4.49%	564,127.00	4.65%
comm_serv	75,204.82	0.36%	84,890.58	0.40%	99,166.00	0.47%	101,700.00	0.51%	96,989.00	0.59%	95,198.00	0.64%	88,192.00	0.68%	90,934.00	0.75%
trade_serv	3,042,551.89	14.76%	3,193,810.59	15.20%	3,383,565.00	16.10%	3,241,117.00	16.40%	3,024,753.00	18.27%	2,826,202.00	18.94%	2,722,595.00	20.94%	2,522,796.00	20.78%
non_manuf_serv	1,185.56	0.01%	1,686.68	0.01%	3,114.00	0.01%	3,838.00	0.02%	4,288.00	0.03%	5,567.00	0.04%	6,318.00	0.05%	9,210.00	0.08%
hous_serv	141,556.02	0.69%	163,459.42	0.78%	182,793.00	0.87%	203,918.00	1.03%	240,242.00	1.45%	255,896.00	1.72%	279,059.00	2.15%	309,390.00	2.55%
health_educ_serv	884,869.86	4.29%	922,724.54	4.39%	1,020,845.00	4.86%	1,027,122.00	5.20%	1,013,291.00	6.12%	973,793.00	6.53%	949,665.00	7.30%	907,235.00	7.47%
r_d_serv	172,907.78	0.84%	183,215.75	0.87%	194,504.00	0.93%	186,666.00	0.94%	120,612.00	0.73%	114,265.00	0.77%	96,054.00	0.74%	97,261.00	0.80%
fin_serv	3,292,999.94	15.97%	3,165,009.05	15.06%	2,989,382.00	14.23%	3,043,517.00	15.40%	2,096,210.00	12.66%	1,818,084.00	12.19%	1,585,491.00	12.20%	1,252,057.00	10.31%

Table B.7: Accounting output multipliers

Industry	1996 Output	1996 Share	1997 Output	1997 Share	1998 Output	1998 Share	1999 Output	1999 Share	2000 Output	2000 Share	2001 Output	2001 Share	2002 Output	2002 Share	2003 Output	2003 Share
elec	68,302.83	0.60%	69,681.82	0.61%	69,702.27	0.64%	72,379.79	0.64%	72,942.56	0.58%	85,085.87	0.65%	87,989.10	0.64%	95,498.66	0.65%
oil_exc	476,378.74	4.17%	470,780.43	4.10%	492,710.58	4.51%	489,133.52	4.29%	525,478.71	4.20%	574,497.00	4.37%	639,368.86	4.65%	739,032.10	5.01%
oil_proc	448,113.61	3.92%	438,999.48	3.82%	387,357.31	3.55%	371,012.60	3.26%	400,461.79	3.20%	380,106.82	2.89%	420,051.40	3.05%	415,422.97	2.82%
gas	81,112.91	0.71%	79,574.17	0.69%	80,688.13	0.74%	82,166.23	0.72%	78,622.72	0.63%	67,137.51	0.51%	72,906.45	0.53%	77,818.44	0.53%
coal	25,218.74	0.22%	21,787.06	0.19%	22,438.58	0.21%	27,000.47	0.24%	33,211.70	0.27%	39,659.52	0.30%	38,629.65	0.28%	47,719.39	0.32%
oil_shales	47.63	0.00%	68.13	0.00%	83.90	0.00%	128.89	0.00%	190.12	0.00%	221.87	0.00%	212.89	0.00%	232.46	0.00%
fer_met	353,938.28	3.10%	338,508.71	2.95%	337,178.94	3.09%	323,241.17	2.84%	330,038.97	2.64%	312,508.41	2.38%	337,296.24	2.45%	389,616.89	2.64%
non_fer_met	409,246.20	3.58%	432,039.21	3.76%	417,097.44	3.82%	456,838.34	4.01%	530,385.68	4.24%	512,887.94	3.90%	525,799.84	3.82%	550,337.97	3.73%
chem	167,495.35	1.47%	176,199.59	1.53%	184,828.57	1.69%	233,118.65	2.05%	285,266.03	2.28%	319,819.93	2.43%	316,934.34	2.30%	319,771.20	2.17%
machin	811,735.00	7.11%	828,627.25	7.22%	727,688.11	6.66%	822,925.71	7.23%	981,258.05	7.84%	1,039,841.97	7.91%	1,075,282.57	7.82%	1,126,177.50	7.64%
wood	94,135.63	0.82%	103,367.86	0.90%	111,428.23	1.02%	153,420.64	1.35%	181,913.76	1.45%	175,551.92	1.34%	187,773.21	1.37%	184,756.78	1.25%
build_mat	28,538.74	0.25%	27,285.74	0.24%	27,080.52	0.25%	28,855.80	0.25%	30,265.77	0.24%	19,209.61	0.15%	11,987.01	0.09%	11,296.62	0.08%
textiles	105,041.79	0.92%	101,816.46	0.89%	88,296.07	0.81%	97,721.13	0.86%	122,503.66	0.98%	129,117.94	0.98%	124,368.03	0.90%	121,853.74	0.83%
food	938,459.00	8.22%	913,302.72	7.95%	914,474.09	8.37%	983,832.84	8.64%	1,091,937.25	8.73%	1,198,344.53	9.12%	1,249,724.86	9.08%	1,292,473.50	8.77%
manuf_goods	97,380.98	0.85%	92,458.23	0.81%	89,882.60	0.82%	97,494.49	0.86%	108,878.47	0.87%	124,491.65	0.95%	122,043.72	0.89%	105,206.92	0.71%
constr	1,011,789.77	8.86%	1,012,692.19	8.82%	937,511.36	8.58%	1,031,744.89	9.06%	1,169,755.31	9.35%	1,277,017.35	9.71%	1,251,584.73	9.10%	1,412,453.43	9.58%
agr_prod	738,866.89	6.47%	748,440.75	6.52%	613,955.46	5.62%	637,711.72	5.60%	672,884.91	5.38%	722,466.51	5.50%	714,108.92	5.19%	732,186.12	4.97%
trans	542,266.43	4.75%	509,528.99	4.44%	475,226.76	4.35%	494,712.07	4.34%	539,515.31	4.31%	567,289.73	4.32%	610,597.78	4.44%	674,854.90	4.58%
comm_serv	92,793.81	0.81%	92,151.30	0.80%	95,711.18	0.88%	122,177.03	1.07%	141,391.89	1.13%	164,365.97	1.25%	187,862.89	1.37%	221,292.57	1.50%
trade_serv	2,471,085.84	21.64%	2,444,880.46	21.29%	2,289,462.53	20.96%	2,235,703.30	19.63%	2,495,154.32	19.94%	2,600,332.54	19.78%	2,834,786.59	20.61%	3,161,164.27	21.45%
non_manuf_serv	8,796.27	0.08%	12,393.78	0.11%	16,637.84	0.15%	19,300.59	0.17%	27,554.57	0.22%	31,678.52	0.24%	31,866.23	0.23%	32,034.33	0.22%
hous_serv	311,667.04	2.73%	343,072.60	2.99%	356,424.46	3.26%	375,256.00	3.29%	393,737.87	3.15%	430,683.71	3.28%	453,272.81	3.30%	493,106.92	3.35%
health_educ_serv	862,619.84	7.55%	887,694.54	7.73%	881,146.20	8.07%	896,866.14	7.87%	922,849.51	7.38%	920,184.65	7.00%	954,657.12	6.94%	974,813.43	6.61%
r_d_serv	95,236.94	0.83%	105,433.70	0.92%	94,644.71	0.87%	89,840.49	0.79%	94,728.91	0.76%	95,034.92	0.72%	94,555.64	0.69%	104,199.97	0.71%
fin_serv	1,178,305.42	10.32%	1,230,756.11	10.72%	1,209,369.51	11.07%	1,244,664.88	10.93%	1,280,147.11	10.23%	1,356,028.46	10.32%	1,410,528.19	10.25%	1,455,108.20	9.87%

Industry	2004 Output	2004 Share	2005 Output	2005 Share	2006 Output	2006 Share
elec	92,349.00	0.59%	102,532.00	0.61%	109,340.00	0.61%
oil_exc	829,555.00	5.28%	841,983.00	5.04%	843,017.00	4.71%
oil_proc	426,462.00	2.71%	449,986.00	2.70%	483,716.00	2.70%
gas	80,150.00	0.51%	81,320.00	0.49%	78,483.00	0.44%
coal	51,040.00	0.32%	59,938.00	0.36%	60,300.00	0.34%
oil_shales	164.00	0.00%	121.00	0.00%	43.00	0.00%
fer_met	404,323.00	2.57%	417,128.00	2.50%	458,749.00	2.57%
non_fer_met	559,192.00	3.56%	583,743.00	3.50%	641,786.00	3.59%
chem	342,670.00	2.18%	359,433.00	2.15%	398,083.00	2.23%
machin	1,243,700.00	7.91%	1,332,297.00	7.98%	1,374,154.00	7.68%
wood	183,413.00	1.17%	200,449.00	1.20%	209,752.00	1.17%
build_mat	24,836.00	0.16%	20,511.00	0.12%	24,893.00	0.14%
textiles	111,358.00	0.71%	110,385.00	0.66%	120,572.00	0.67%
food	1,288,515.00	8.20%	1,349,596.00	8.08%	1,407,239.00	7.87%
manuf_goods	122,648.00	0.78%	125,692.00	0.75%	127,865.00	0.72%
constr	1,542,137.00	9.81%	1,666,659.00	9.98%	1,925,286.00	10.77%
agr_prod	799,253.00	5.09%	820,489.00	4.91%	851,740.00	4.76%
trans	694,759.00	4.42%	711,411.00	4.26%	741,600.00	4.15%
comm_serv	266,021.00	1.69%	279,258.00	1.67%	318,614.00	1.78%
trade_serv	3,539,702.00	22.53%	3,943,085.00	23.62%	4,265,282.00	23.85%
non_manuf_serv	30,682.00	0.20%	36,269.00	0.22%	44,898.00	0.25%
hous_serv	490,518.00	3.12%	518,571.00	3.11%	552,975.00	3.09%
health_educ_serv	977,141.00	6.22%	1,001,648.00	6.00%	1,035,340.00	5.79%
r_d_serv	105,658.00	0.67%	109,634.00	0.66%	121,897.00	0.68%
fin_serv	1,505,064.00	9.58%	1,569,488.00	9.40%	1,685,037.00	9.42%

Accounting output multipliers - continued

Year	elec	oil_exc	oil_proc	gas	coal	oil_shales	fer_met	non_fer_met	chem	machin	wood	build_mat	textiles
1980	0.08	0.03	0.01	0.02	0.27	0.52	0.08	0.09	0.08	0.17	0.21	0.17	0.07
1981	0.08	0.03	0.01	0.01	0.29	0.50	0.08	0.09	0.08	0.17	0.21	0.17	0.08
1982	0.08	0.03	0.01	0.01	0.26	0.47	0.08	0.09	0.08	0.17	0.20	0.17	0.08
1983	0.08	0.02	0.01	0.01	0.23	0.43	0.07	0.06	0.08	0.16	0.19	0.15	0.09
1984	0.08	0.02	0.01	0.01	0.24	0.43	0.07	0.06	0.08	0.16	0.19	0.15	0.08
1985	0.08	0.03	0.01	0.01	0.24	0.44	0.07	0.06	0.08	0.15	0.19	0.15	0.08
1986	0.08	0.03	0.01	0.01	0.23	0.41	0.07	0.06	0.07	0.14	0.18	0.15	0.08
1987	0.06	0.03	0.01	0.01	0.25	0.38	0.08	0.06	0.07	0.15	0.19	0.16	0.08
1988	0.06	0.04	0.01	0.01	0.26	0.42	0.08	0.06	0.07	0.16	0.19	0.18	0.08
1989	0.07	0.04	0.01	0.01	0.28	0.42	0.08	0.07	0.07	0.16	0.19	0.17	0.08
1990	0.08	0.05	0.01	0.01	0.31	0.44	0.09	0.06	0.07	0.19	0.20	0.18	0.09
1991	0.14	0.07	0.01	0.05	0.04	0.59	0.11	0.07	0.08	0.17	0.16	0.20	0.07
1992	0.07	0.04	0.02	0.02	0.26	0.32	0.08	0.07	0.09	0.17	0.18	0.26	0.14
1993	0.10	0.17	0.09	0.06	0.41	0.67	0.11	0.13	0.12	0.26	0.34	0.40	0.25
1994	0.08	0.17	0.16	0.06	0.38	0.46	0.15	0.22	0.17	0.34	0.39	0.32	0.39
1995	0.14	0.07	0.04	0.06	0.28	0.21	0.10	0.13	0.11	0.22	0.20	0.18	0.23
1996	0.12	0.09	0.04	0.14	0.35	0.32	0.14	0.20	0.14	0.24	0.26	0.20	0.25
1997	0.11	0.11	0.04	0.16	0.35	0.36	0.14	0.18	0.16	0.26	0.27	0.23	0.20
1998	0.12	0.11	0.04	0.16	0.34	0.44	0.14	0.13	0.16	0.28	0.24	0.23	0.22
1999	0.16	0.08	0.03	0.13	0.36	0.37	0.11	0.08	0.12	0.20	0.17	0.21	0.17
2000	0.17	0.07	0.02	0.12	0.34	0.49	0.12	0.12	0.13	0.21	0.18	0.21	0.17
2001	0.17	0.12	0.02	0.17	0.29	0.82	0.14	0.13	0.14	0.23	0.19	0.22	0.17
2002	0.16	0.11	0.03	0.13	0.29	0.86	0.14	0.13	0.16	0.25	0.19	0.25	0.19
2003	0.15	0.10	0.03	0.16	0.27	0.50	0.11	0.13	0.15	0.25	0.19	0.23	0.19
2004	0.14	0.10	0.03	0.15	0.25	0.46	0.11	0.12	0.14	0.23	0.18	0.21	0.17
2005	0.14	0.10	0.03	0.15	0.25	0.46	0.11	0.12	0.14	0.23	0.18	0.21	0.17
2006	0.14	0.10	0.03	0.15	0.26	0.47	0.11	0.12	0.14	0.24	0.18	0.22	0.18

Year	food	manuf_goods	constr	agr_prod	trans	comm_serv	trade_serv	non_manuf_serv	hous_serv	health_educ_serv	r_d_serv	fin_serv
1980	0.04	0.10	0.46	0.28	0.32	0.44	0.38	0.13	0.70	0.59	0.59	0.15
1981	0.04	0.10	0.47	0.28	0.32	0.44	0.38	0.09	0.68	0.59	0.63	0.15
1982	0.03	0.10	0.43	0.26	0.32	0.44	0.46	0.08	0.63	0.57	0.60	0.13
1983	0.04	0.12	0.45	0.23	0.28	0.41	0.45	0.11	0.63	0.58	0.61	0.11
1984	0.04	0.12	0.42	0.23	0.28	0.41	0.45	0.11	0.61	0.57	0.59	0.12
1985	0.04	0.12	0.43	0.23	0.30	0.47	0.45	0.13	0.62	0.58	0.56	0.11
1986	0.04	0.12	0.43	0.22	0.29	0.47	0.45	0.12	0.59	0.56	0.56	0.11
1987	0.04	0.12	0.40	0.25	0.27	0.43	0.41	0.13	0.61	0.59	0.51	0.12
1988	0.04	0.13	0.45	0.22	0.29	0.47	0.41	0.14	0.68	0.64	0.59	0.12
1989	0.04	0.11	0.43	0.21	0.28	0.41	0.42	0.13	0.68	0.55	0.53	0.15
1990	0.04	0.10	0.47	0.21	0.27	0.44	0.45	0.10	0.69	0.59	0.66	0.26
1991	0.04	0.08	0.36	0.18	0.31	0.57	0.19	0.10	0.50	0.55	0.37	0.40
1992	0.08	0.15	0.29	0.23	0.14	0.37	0.07	0.08	0.43	0.50	0.81	0.31
1993	0.12	0.42	0.23	0.25	0.18	0.27	0.17	0.26	0.22	0.49	0.70	0.37
1994	0.12	0.51	0.30	0.20	0.28	0.02	0.27	0.22	0.26	0.41	0.60	0.40
1995	0.09	0.29	0.28	0.13	0.23	0.29	0.10	0.58	0.18	0.39	0.33	0.36
1996	0.12	0.16	0.28	0.14	0.30	0.10	0.10	0.34	0.22	0.45	0.49	0.36
1997	0.12	0.23	0.28	0.14	0.30	0.11	0.11	0.29	0.23	0.38	0.40	0.38
1998	0.11	0.17	0.26	0.10	0.29	0.11	0.10	0.32	0.25	0.43	0.43	0.47
1999	0.08	0.11	0.22	0.09	0.28	0.11	0.06	0.38	0.28	0.45	0.38	0.41
2000	0.09	0.12	0.21	0.10	0.30	0.11	0.06	0.38	0.31	0.45	0.38	0.42
2001	0.09	0.14	0.20	0.10	0.27	0.12	0.06	0.33	0.31	0.46	0.37	0.39
2002	0.09	0.15	0.22	0.11	0.25	0.28	0.08	0.33	0.32	0.53	0.44	0.42
2003	0.10	0.18	0.22	0.11	0.26	0.30	0.08	0.37	0.33	0.53	0.44	0.41
2004	0.09	0.17	0.20	0.10	0.24	0.28	0.07	0.34	0.31	0.49	0.41	0.38
2005	0.09	0.17	0.20	0.10	0.24	0.27	0.07	0.34	0.31	0.48	0.40	0.38
2006	0.09	0.17	0.20	0.10	0.25	0.28	0.07	0.34	0.32	0.50	0.41	0.40

Table B.8: Labor-input coefficients

Industry	1980						1981						1982						1983					
	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank
elec	0.55	11	0.39	13	0.19	22	0.55	11	0.38	13	0.19	22	0.50	12	0.42	13	0.19	21	0.50	13	0.41	12	0.18	21
oil_exc	0.60	10	0.34	16	0.14	24	0.60	10	0.34	16	0.15	24	0.60	8	0.33	18	0.13	24	0.60	8	0.33	17	0.12	24
oil_proc	0.17	21	0.72	2	0.18	23	0.15	24	0.74	2	0.19	23	0.18	22	0.70	2	0.18	23	0.19	24	0.69	2	0.17	23
gas	0.67	4	0.28	22	0.11	25	0.68	3	0.27	22	0.11	25	0.70	3	0.25	23	0.09	25	0.70	3	0.25	23	0.08	25
coal	0.61	7	0.32	18	0.31	13	0.61	8	0.32	18	0.33	13	0.58	9	0.35	15	0.30	12	0.57	9	0.35	15	0.27	13
oil_shales	0.67	3	0.28	23	0.48	5	0.67	4	0.27	23	0.46	5	0.76	1	0.20	25	0.39	8	0.76	1	0.19	25	0.36	8
fer_met	0.16	22	0.63	3	0.28	14	0.15	23	0.63	3	0.28	14	0.18	24	0.61	3	0.26	15	0.19	23	0.59	3	0.23	15
non_fer_met	0.26	20	0.52	7	0.23	20	0.26	20	0.51	7	0.22	19	0.28	20	0.53	5	0.21	19	0.27	20	0.52	7	0.17	22
chem	0.27	19	0.56	5	0.24	18	0.27	19	0.55	5	0.24	18	0.30	19	0.52	6	0.21	17	0.30	18	0.52	6	0.21	18
machin	0.13	24	0.61	4	0.35	10	0.16	21	0.58	4	0.34	11	0.18	23	0.57	4	0.31	11	0.21	22	0.54	5	0.28	11
wood	0.36	17	0.50	9	0.33	12	0.35	17	0.50	9	0.33	12	0.37	17	0.47	9	0.29	13	0.38	17	0.47	9	0.28	12
build_mat	0.42	16	0.47	10	0.28	15	0.43	15	0.46	10	0.28	15	0.43	16	0.45	10	0.26	14	0.42	16	0.45	10	0.24	14
textiles	0.14	23	0.51	8	0.25	17	0.15	22	0.50	8	0.24	17	0.22	21	0.49	8	0.21	18	0.22	21	0.48	8	0.21	17
food	0.32	18	0.53	6	0.20	21	0.33	18	0.52	6	0.20	21	0.32	18	0.52	7	0.18	22	0.29	19	0.56	4	0.19	20
manuf_goods	-0.34	25	1.01	1	0.44	7	-0.34	25	0.99	1	0.45	6	-0.25	25	0.95	1	0.40	7	-0.20	25	0.93	1	0.37	7
constr	0.53	12	0.36	15	0.45	6	0.52	12	0.36	15	0.45	7	0.53	11	0.34	16	0.40	6	0.53	11	0.34	16	0.41	6
agr_prod	0.45	15	0.43	12	0.36	9	0.41	16	0.44	11	0.37	9	0.44	15	0.42	12	0.32	10	0.46	15	0.41	13	0.28	10
trans	0.61	9	0.32	19	0.35	11	0.61	6	0.31	19	0.34	10	0.61	7	0.31	20	0.33	9	0.62	6	0.30	20	0.29	9
comm_serv	0.47	14	0.47	11	0.56	3	0.50	14	0.44	12	0.54	3	0.48	14	0.45	11	0.51	3	0.51	12	0.42	11	0.47	4
trade_serv	0.69	1	0.26	25	0.38	8	0.68	2	0.27	24	0.38	8	0.66	4	0.28	21	0.42	5	0.66	4	0.28	21	0.41	5
non_manuf_serv	0.61	6	0.30	20	0.23	19	0.60	9	0.30	20	0.20	20	0.54	10	0.34	17	0.20	20	0.56	10	0.32	18	0.20	19
hous_serv	0.61	8	0.33	17	0.64	1	0.61	7	0.33	17	0.62	1	0.61	6	0.32	19	0.55	1	0.61	7	0.32	19	0.55	1
health_educ_serv	0.65	5	0.29	21	0.54	4	0.65	5	0.29	21	0.54	4	0.65	5	0.28	22	0.49	4	0.66	5	0.27	22	0.50	3
r_d_serv	0.68	2	0.28	24	0.56	2	0.69	1	0.27	25	0.58	2	0.70	2	0.25	24	0.52	2	0.72	2	0.24	24	0.53	2
fin_serv	0.50	13	0.38	14	0.27	16	0.51	13	0.37	14	0.27	16	0.50	13	0.37	14	0.24	16	0.48	14	0.38	14	0.22	16

Industry	1984						1985						1986						1987					
	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank
elec	0.51	13	0.39	12	0.17	22	0.52	12	0.39	12	0.17	22	0.52	12	0.39	11	0.16	22	0.48	14	0.42	11	0.16	22
oil_exc	0.60	8	0.32	18	0.12	24	0.61	8	0.32	18	0.12	24	0.60	8	0.33	17	0.12	24	0.60	7	0.33	17	0.12	24
oil_proc	0.14	24	0.72	2	0.18	21	0.18	23	0.69	2	0.17	21	0.19	23	0.68	2	0.16	21	0.20	23	0.68	2	0.17	21
gas	0.72	2	0.23	24	0.08	25	0.73	2	0.22	24	0.07	25	0.72	3	0.23	23	0.07	25	0.71	2	0.23	24	0.07	25
coal	0.56	9	0.36	15	0.28	10	0.55	9	0.36	15	0.28	10	0.55	10	0.37	15	0.26	10	0.56	9	0.34	16	0.28	10
oil_shales	0.78	1	0.17	25	0.36	8	0.79	1	0.17	25	0.36	8	0.78	1	0.18	25	0.32	8	0.80	1	0.15	25	0.31	8
fer_met	0.20	22	0.58	3	0.22	16	0.20	22	0.57	3	0.22	16	0.21	21	0.56	4	0.20	18	0.23	22	0.53	4	0.21	18
non_fer_met	0.28	20	0.51	6	0.17	23	0.27	20	0.50	6	0.16	23	0.26	20	0.48	6	0.15	23	0.23	21	0.45	8	0.16	23
chem	0.32	18	0.50	7	0.20	19	0.32	18	0.49	7	0.19	20	0.34	18	0.48	7	0.17	20	0.33	18	0.47	5	0.18	20
machin	0.22	21	0.52	5	0.27	13	0.24	21	0.50	5	0.26	13	0.27	19	0.48	5	0.23	13	0.28	19	0.45	6	0.24	13
wood	0.38	17	0.46	9	0.28	12	0.37	17	0.46	9	0.27	12	0.37	17	0.46	9	0.25	12	0.40	17	0.44	9	0.26	12
build_mat	0.42	16	0.44	10	0.24	14	0.41	16	0.45	10	0.23	14	0.41	16	0.44	10	0.21	14	0.43	16	0.42	10	0.23	14
textiles	0.19	23	0.48	8	0.22	17	0.17	24	0.47	8	0.21	18	0.19	22	0.46	8	0.19	19	0.25	20	0.45	7	0.19	19
food	0.28	19	0.55	4	0.19	20	0.27	19	0.56	4	0.19	19	0.19	24	0.62	3	0.20	16	0.18	24	0.61	3	0.22	15
manuf_goods	-0.18	25	0.91	1	0.36	7	-0.20	25	0.91	1	0.36	7	-0.21	25	0.91	1	0.33	7	-0.21	25	0.85	1	0.35	7
constr	0.51	12	0.34	16	0.39	6	0.52	13	0.34	17	0.39	6	0.53	11	0.32	18	0.36	6	0.50	13	0.35	14	0.38	5
agr_prod	0.47	15	0.39	13	0.28	11	0.46	15	0.40	11	0.27	11	0.48	15	0.39	12	0.25	11	0.48	15	0.38	12	0.29	9
trans	0.62	6	0.29	20	0.29	9	0.62	6	0.29	20	0.29	9	0.64	6	0.28	21	0.28	9	0.63	6	0.29	20	0.28	11
comm_serv	0.53	11	0.40	11	0.46	4	0.55	10	0.38	13	0.49	2	0.57	9	0.37	14	0.46	2	0.56	10	0.38	13	0.45	3
trade_serv	0.67	4	0.27	21	0.41	5	0.67	4	0.27	21	0.40	5	0.65	5	0.28	20	0.38	5	0.68	4	0.26	22	0.37	6
non_manuf_serv	0.55	10	0.33	17	0.20	18	0.53	11	0.34	16	0.22	15	0.52	13	0.34	16	0.21	15	0.53	11	0.31	19	0.21	17
hous_serv	0.61	7	0.32	19	0.54	1	0.61	7	0.31	19	0.52	1	0.61	7	0.32	19	0.49	1	0.60	8	0.32	18	0.53	1
health_educ_serv	0.66	5	0.27	22	0.49	3	0.66	5	0.27	22	0.48	3	0.66	4	0.27	22	0.46	3	0.65	5	0.27	21	0.50	2
r_d_serv	0.71	3	0.24	23	0.52	2	0.72	3	0.23	23	0.47	4	0.73	2	0.22	24	0.45	4	0.70	3	0.24	23	0.45	4
fin_serv	0.48	14	0.37	14	0.23	15	0.47	14	0.38	14	0.21	17	0.48	14	0.37	13	0.20	17	0.50	12	0.35	15	0.21	16

Table B.9: Direct, indirect and induced effects of Type II GDP-output multipliers

	1988						1989						1990						1991					
Industry	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank
elec	0.49	14	0.42	10	0.17	22	0.50	13	0.40	10	0.18	22	0.50	13	0.41	10	0.19	21	0.50	13	0.43	12	0.25	16
oil_exc	0.59	8	0.34	18	0.14	24	0.59	7	0.33	17	0.14	24	0.60	6	0.33	18	0.15	24	0.62	6	0.33	20	0.18	23
oil_proc	0.21	23	0.68	2	0.17	21	0.21	24	0.67	1	0.18	20	0.15	24	0.73	1	0.20	17	0.14	24	0.74	1	0.19	22
gas	0.71	2	0.23	24	0.08	25	0.71	2	0.23	24	0.08	25	0.72	2	0.22	24	0.08	25	0.73	2	0.23	24	0.12	25
coal	0.57	10	0.34	16	0.28	10	0.58	9	0.33	18	0.31	8	0.57	8	0.34	17	0.33	9	0.56	10	0.36	17	0.15	24
oil_shales	0.77	1	0.18	25	0.34	8	0.77	1	0.18	25	0.36	7	0.80	1	0.16	25	0.35	7	0.81	1	0.16	25	0.58	3
fer_met	0.23	22	0.53	4	0.21	17	0.24	20	0.50	4	0.22	16	0.27	20	0.51	4	0.23	16	0.31	20	0.53	4	0.29	14
non_fer_met	0.23	21	0.44	9	0.16	23	0.21	22	0.41	9	0.17	23	0.18	23	0.46	5	0.18	22	0.19	23	0.53	5	0.24	17
chem	0.36	18	0.46	6	0.18	20	0.38	18	0.44	7	0.18	21	0.38	18	0.44	8	0.18	23	0.41	18	0.47	8	0.22	20
machin	0.25	19	0.47	5	0.26	12	0.25	19	0.45	5	0.27	11	0.29	19	0.45	7	0.29	11	0.32	19	0.48	6	0.32	9
wood	0.40	17	0.44	8	0.27	11	0.42	17	0.42	8	0.27	10	0.43	17	0.42	9	0.27	13	0.45	16	0.45	9	0.29	13
build_mat	0.46	16	0.41	11	0.24	14	0.46	16	0.40	11	0.24	15	0.47	15	0.41	11	0.25	15	0.46	15	0.44	11	0.32	11
textiles	0.24	20	0.45	7	0.19	19	0.22	21	0.44	6	0.20	18	0.26	21	0.45	6	0.20	19	0.25	22	0.48	7	0.21	21
food	0.16	24	0.63	3	0.22	16	0.21	23	0.60	2	0.21	17	0.24	22	0.59	3	0.20	18	0.26	21	0.60	3	0.22	19
manuf_goods	-0.29	25	0.91	1	0.36	7	0.09	25	0.58	3	0.26	13	-0.04	25	0.68	2	0.28	12	0.02	25	0.71	2	0.32	10
constr	0.52	12	0.35	14	0.40	5	0.52	12	0.34	15	0.40	5	0.55	11	0.33	19	0.42	5	0.53	11	0.36	14	0.44	7
agr_prod	0.48	15	0.38	12	0.26	13	0.46	15	0.39	12	0.27	12	0.46	16	0.40	12	0.26	14	0.44	17	0.45	10	0.30	12
trans	0.62	7	0.30	19	0.29	9	0.62	6	0.29	20	0.30	9	0.60	7	0.32	20	0.29	10	0.60	7	0.34	19	0.39	8
comm_serv	0.56	11	0.37	13	0.49	4	0.57	11	0.36	13	0.46	4	0.57	9	0.36	13	0.47	4	0.59	8	0.35	18	0.69	1
trade_serv	0.68	3	0.26	22	0.37	6	0.69	3	0.25	23	0.39	6	0.71	3	0.23	23	0.39	6	0.72	3	0.24	23	0.25	15
non_manuf_serv	0.63	6	0.26	23	0.20	18	0.57	10	0.30	19	0.20	19	0.48	14	0.35	15	0.19	20	0.49	14	0.38	13	0.23	18
hous_serv	0.58	9	0.34	17	0.58	1	0.58	8	0.34	16	0.60	1	0.57	10	0.35	14	0.60	1	0.57	9	0.36	15	0.57	4
health_educ_serv	0.64	5	0.28	20	0.53	2	0.63	5	0.29	21	0.50	3	0.61	5	0.31	21	0.51	3	0.62	5	0.32	21	0.59	2
r_d_serv	0.68	4	0.27	21	0.51	3	0.67	4	0.27	22	0.50	2	0.64	4	0.30	22	0.60	2	0.64	4	0.31	22	0.46	6
fin_serv	0.51	13	0.35	15	0.22	15	0.49	14	0.35	14	0.25	14	0.51	12	0.35	16	0.33	8	0.52	12	0.36	16	0.49	5

	1992						1993						1994						1995					
Industry	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank
elec	0.52	12	0.42	13	0.21	22	0.53	13	0.40	12	0.25	24	0.53	12	0.40	10	0.25	23	0.53	11	0.40	10	0.37	20
oil_exc	0.63	5	0.32	21	0.22	21	0.65	4	0.30	22	0.35	20	0.68	4	0.27	22	0.32	22	0.69	4	0.26	22	0.24	24
oil_proc	0.09	24	0.80	1	0.20	23	0.02	25	0.85	1	0.38	16	-0.05	25	0.91	1	0.50	11	-0.02	25	0.88	1	0.31	22
gas	0.75	2	0.22	24	0.09	25	0.74	2	0.23	23	0.14	25	0.74	3	0.21	23	0.14	24	0.74	2	0.21	23	0.18	25
coal	0.54	11	0.39	15	0.50	9	0.54	12	0.38	14	0.63	5	0.52	14	0.37	12	0.57	6	0.50	14	0.38	12	0.61	6
oil_shales	0.77	1	0.20	25	0.47	11	0.78	1	0.18	25	0.80	3	0.75	2	0.20	25	0.55	7	0.74	3	0.20	25	0.39	16
fer_met	0.29	21	0.56	4	0.32	16	0.25	23	0.54	4	0.37	19	0.28	23	0.45	7	0.37	19	0.32	21	0.43	7	0.35	21
non_fer_met	0.25	23	0.56	5	0.30	19	0.29	21	0.52	5	0.37	18	0.30	22	0.50	4	0.49	12	0.31	22	0.49	4	0.45	14
chem	0.36	18	0.53	6	0.30	17	0.35	19	0.52	6	0.35	21	0.35	20	0.49	5	0.39	18	0.37	20	0.46	5	0.38	18
machin	0.35	19	0.49	9	0.44	12	0.38	18	0.43	9	0.50	11	0.42	17	0.37	13	0.54	9	0.42	18	0.37	13	0.51	10
wood	0.43	16	0.48	10	0.41	13	0.44	16	0.46	8	0.60	7	0.41	18	0.47	6	0.67	3	0.43	17	0.45	6	0.51	9
build_mat	0.46	15	0.46	11	0.49	10	0.47	15	0.42	11	0.63	6	0.44	16	0.43	8	0.53	10	0.43	16	0.43	8	0.45	13
textiles	0.31	20	0.50	7	0.38	15	0.30	20	0.43	10	0.50	12	0.40	19	0.35	15	0.59	5	0.41	19	0.30	19	0.48	12
food	0.27	22	0.61	3	0.39	14	0.28	22	0.59	3	0.43	15	0.31	21	0.57	3	0.37	20	0.28	23	0.58	2	0.38	17
manuf_goods	0.08	25	0.72	2	0.50	8	0.12	24	0.68	2	0.81	2	0.18	24	0.61	2	0.85	2	0.23	24	0.56	3	0.71	3
constr	0.51	13	0.39	14	0.53	6	0.54	11	0.35	17	0.44	14	0.58	8	0.29	20	0.46	14	0.57	9	0.30	20	0.56	8
agr_prod	0.40	17	0.50	8	0.52	7	0.44	17	0.46	7	0.50	10	0.49	15	0.42	9	0.39	17	0.48	15	0.41	9	0.37	19
trans	0.60	9	0.35	18	0.29	20	0.59	8	0.34	19	0.34	22	0.56	9	0.35	14	0.44	15	0.56	10	0.36	14	0.50	11
comm_serv	0.63	4	0.33	20	0.64	4	0.64	5	0.31	21	0.44	13	0.66	5	0.29	21	0.13	25	0.67	5	0.28	21	0.58	7
trade_serv	0.72	3	0.24	23	0.17	24	0.74	3	0.22	24	0.28	23	0.75	1	0.21	24	0.37	21	0.75	1	0.20	24	0.25	23
non_manuf_serv	0.48	14	0.43	12	0.30	18	0.50	14	0.39	13	0.55	9	0.54	11	0.34	17	0.47	13	0.51	13	0.35	15	1.10	1
hous_serv	0.60	8	0.35	19	0.67	3	0.59	7	0.34	18	0.38	17	0.60	7	0.33	18	0.40	16	0.60	6	0.33	17	0.42	15
health_educ_serv	0.63	6	0.32	22	0.76	2	0.62	6	0.32	20	0.66	4	0.62	6	0.31	19	0.54	8	0.60	7	0.31	18	0.71	4
r_d_serv	0.60	7	0.35	17	1.31	1	0.58	9	0.36	15	1.03	1	0.52	13	0.39	11	0.88	1	0.51	12	0.39	11	0.73	2
fin_serv	0.54	10	0.38	16	0.61	5	0.55	10	0.35	16	0.60	8	0.56	10	0.34	16	0.59	4	0.58	8	0.33	16	0.69	5

Direct, indirect and induced effects of Type II GDP-output multipliers - continued

Industry	1996 Direct	Rank	Indirect	Rank	Induced	Rank	1997 Direct	Rank	Indirect	Rank	Induced	Rank	1998 Direct	Rank	Indirect	Rank	Induced	Rank	1999 Direct	Rank	Indirect	Rank	Induced	Rank
elec	0.53	14	0.39	10	0.31	20	0.53	11	0.39	10	0.30	20	0.53	11	0.39	9	0.31	19	0.53	12	0.40	10	0.38	13
oil_exc	0.69	4	0.25	20	0.27	22	0.70	5	0.24	20	0.28	22	0.71	5	0.24	20	0.27	21	0.71	5	0.24	21	0.24	22
oil_proc	0.17	25	0.70	1	0.26	23	0.18	25	0.71	1	0.28	23	0.20	25	0.69	1	0.26	23	0.20	25	0.71	1	0.23	23
gas	0.74	2	0.21	23	0.27	21	0.74	2	0.20	23	0.30	21	0.75	4	0.20	22	0.29	20	0.75	2	0.21	23	0.27	20
coal	0.51	15	0.36	11	0.67	3	0.52	12	0.35	15	0.67	3	0.52	12	0.35	15	0.63	5	0.53	11	0.36	15	0.72	4
oil_shales	0.73	3	0.20	24	0.51	10	0.73	4	0.20	24	0.59	6	0.81	1	0.14	25	0.63	4	0.73	4	0.20	24	0.62	6
fer_met	0.34	21	0.39	9	0.38	18	0.35	21	0.40	9	0.39	17	0.38	21	0.38	10	0.36	17	0.39	21	0.43	6	0.35	16
non_fer_met	0.35	20	0.45	4	0.52	9	0.37	20	0.45	4	0.48	13	0.40	18	0.46	4	0.37	16	0.42	18	0.47	4	0.29	19
chem	0.33	22	0.44	5	0.40	16	0.35	22	0.43	7	0.42	15	0.37	22	0.41	8	0.39	14	0.40	20	0.43	7	0.36	14
machin	0.39	18	0.35	13	0.50	11	0.40	18	0.35	14	0.54	11	0.38	20	0.35	13	0.54	7	0.38	22	0.39	11	0.46	11
wood	0.40	17	0.43	7	0.58	5	0.42	17	0.42	8	0.59	5	0.42	17	0.42	7	0.52	8	0.43	17	0.42	8	0.43	12
build_mat	0.38	19	0.44	6	0.47	13	0.39	19	0.44	5	0.51	12	0.39	19	0.44	5	0.48	11	0.40	19	0.45	5	0.49	9
textiles	0.56	12	0.24	21	0.44	14	0.51	13	0.23	21	0.38	18	0.48	15	0.23	21	0.38	15	0.45	16	0.27	20	0.35	15
food	0.28	23	0.54	2	0.38	17	0.26	23	0.55	2	0.40	16	0.27	24	0.54	2	0.34	18	0.26	24	0.56	2	0.30	18
manuf_goods	0.24	24	0.52	3	0.48	12	0.25	24	0.51	3	0.58	7	0.33	23	0.48	3	0.43	13	0.33	23	0.51	3	0.34	17
constr	0.57	10	0.28	18	0.53	8	0.48	15	0.35	13	0.56	8	0.48	14	0.35	14	0.50	10	0.47	14	0.38	12	0.48	10
agr_prod	0.53	13	0.35	12	0.32	19	0.53	10	0.36	12	0.33	19	0.53	10	0.36	12	0.26	22	0.54	10	0.37	14	0.24	21
trans	0.56	11	0.34	14	0.53	7	0.56	9	0.35	16	0.55	10	0.56	9	0.34	16	0.51	9	0.58	9	0.34	16	0.52	8
comm_serv	0.69	5	0.26	19	0.25	24	0.74	3	0.22	22	0.25	24	0.75	3	0.20	23	0.24	24	0.80	1	0.17	25	0.23	24
trade_serv	0.75	1	0.20	25	0.23	25	0.76	1	0.19	25	0.23	25	0.76	2	0.19	24	0.21	25	0.74	3	0.21	22	0.18	25
non_manuf_serv	0.65	6	0.23	22	0.57	6	0.62	6	0.26	19	0.56	9	0.60	7	0.29	19	0.57	6	0.59	7	0.30	18	0.68	5
hous_serv	0.60	8	0.31	15	0.42	15	0.59	7	0.32	17	0.45	14	0.61	6	0.31	17	0.46	12	0.59	8	0.33	17	0.54	7
health_educ_serv	0.60	7	0.29	17	0.73	2	0.57	8	0.32	18	0.66	4	0.58	8	0.31	18	0.69	3	0.60	6	0.30	19	0.77	3
r_d_serv	0.45	16	0.41	8	0.99	1	0.44	16	0.43	6	0.85	1	0.45	16	0.42	6	0.86	1	0.47	15	0.42	9	0.81	1
fin_serv	0.60	9	0.30	16	0.64	4	0.50	14	0.38	11	0.73	2	0.52	13	0.37	11	0.81	2	0.52	13	0.37	13	0.78	2

Industry	2000 Direct	Rank	Indirect	Rank	Induced	Rank	2001 Direct	Rank	Indirect	Rank	Induced	Rank	2002 Direct	Rank	Indirect	Rank	Induced	Rank	2003 Direct	Rank	Indirect	Rank	Induced	Rank
elec	0.53	12	0.40	10	0.40	13	0.52	13	0.41	7	0.42	15	0.52	12	0.41	8	0.39	19	0.51	12	0.41	7	0.39	18
oil_exc	0.70	5	0.24	20	0.24	23	0.70	5	0.25	20	0.32	21	0.70	5	0.24	20	0.31	21	0.69	4	0.25	21	0.30	22
oil_proc	0.19	25	0.72	1	0.22	24	0.18	25	0.73	1	0.27	23	0.18	25	0.73	1	0.27	24	0.17	25	0.73	1	0.28	24
gas	0.74	4	0.21	22	0.26	20	0.73	3	0.23	22	0.36	19	0.72	3	0.23	22	0.29	23	0.71	3	0.24	22	0.35	20
coal	0.54	11	0.34	17	0.70	5	0.54	10	0.33	17	0.64	6	0.55	11	0.32	16	0.60	7	0.55	10	0.31	16	0.58	8
oil_shales	0.75	2	0.19	24	0.82	2	0.72	4	0.21	23	1.38	1	0.71	4	0.20	23	1.38	1	0.69	5	0.22	23	0.87	4
fer_met	0.39	19	0.45	3	0.37	14	0.40	19	0.46	4	0.44	13	0.40	19	0.45	4	0.42	16	0.40	19	0.44	4	0.38	19
non_fer_met	0.40	18	0.43	6	0.36	18	0.40	18	0.49	3	0.42	14	0.39	22	0.50	3	0.43	14	0.38	22	0.49	3	0.44	15
chem	0.39	20	0.42	7	0.37	15	0.40	21	0.41	8	0.40	17	0.39	20	0.39	9	0.41	17	0.39	20	0.39	10	0.42	16
machin	0.39	21	0.39	11	0.51	9	0.39	22	0.40	12	0.56	8	0.39	21	0.37	13	0.57	8	0.39	21	0.36	13	0.59	7
wood	0.44	16	0.40	9	0.45	12	0.45	16	0.40	9	0.49	11	0.46	15	0.38	11	0.47	13	0.46	16	0.37	11	0.48	13
build_mat	0.43	17	0.44	5	0.50	10	0.44	17	0.43	6	0.54	10	0.46	16	0.42	6	0.56	9	0.47	15	0.40	9	0.53	11
textiles	0.32	23	0.24	21	0.36	16	0.31	23	0.25	21	0.38	18	0.30	24	0.24	21	0.40	18	0.29	24	0.25	20	0.40	17
food	0.29	24	0.54	2	0.31	19	0.29	24	0.54	2	0.33	20	0.30	23	0.52	2	0.33	20	0.32	23	0.50	2	0.34	21
manuf_goods	0.38	22	0.44	4	0.36	17	0.40	20	0.45	5	0.42	16	0.42	18	0.43	5	0.42	15	0.44	17	0.40	8	0.47	14
constr	0.52	13	0.35	15	0.46	11	0.53	12	0.34	16	0.48	12	0.56	8	0.32	17	0.48	12	0.58	7	0.30	18	0.48	12
agr_prod	0.55	10	0.36	13	0.26	21	0.55	9	0.35	14	0.27	22	0.55	10	0.34	15	0.30	22	0.56	9	0.33	15	0.30	23
trans	0.57	8	0.34	16	0.57	8	0.56	8	0.35	15	0.55	9	0.56	9	0.34	14	0.50	10	0.55	11	0.35	14	0.55	9
comm_serv	0.80	1	0.17	25	0.24	22	0.81	1	0.16	25	0.25	24	0.81	1	0.16	25	0.49	11	0.80	1	0.16	25	0.54	10
trade_serv	0.75	3	0.20	23	0.17	25	0.74	2	0.21	24	0.18	25	0.74	2	0.20	24	0.20	25	0.73	2	0.21	24	0.21	25
non_manuf_serv	0.63	6	0.28	19	0.69	6	0.64	6	0.27	19	0.64	7	0.64	6	0.26	19	0.61	6	0.64	6	0.27	19	0.71	5
hous_serv	0.57	9	0.35	14	0.61	7	0.54	11	0.38	13	0.66	5	0.51	13	0.39	10	0.65	5	0.48	14	0.41	6	0.70	6
health_educ_serv	0.59	7	0.31	18	0.80	4	0.59	7	0.30	18	0.84	2	0.58	7	0.30	18	0.92	3	0.57	8	0.31	17	0.95	1
r_d_serv	0.47	15	0.41	8	0.83	1	0.49	14	0.40	10	0.84	3	0.50	14	0.38	12	0.92	2	0.50	13	0.37	12	0.94	2
fin_serv	0.49	14	0.39	12	0.82	3	0.47	15	0.40	11	0.82	4	0.45	17	0.41	7	0.85	4	0.41	18	0.43	5	0.88	3

Direct, indirect and induced effects of Type II GDP-output multipliers - continued

Industry	2004 Direct	Rank	Indirect	Rank	Induced	Rank	2005 Direct	Rank	Indirect	Rank	Induced	Rank	2006 Direct	Rank	Indirect	Rank	Induced	Rank
elec	0.52	12	0.40	7	0.40	18	0.51	12	0.40	7	0.41	18	0.51	13	0.40	7	0.41	17
oil_exc	0.70	4	0.24	20	0.31	22	0.69	4	0.25	20	0.32	22	0.69	4	0.24	21	0.31	22
oil_proc	0.19	25	0.72	1	0.28	24	0.19	25	0.72	1	0.29	24	0.18	25	0.72	1	0.28	23
gas	0.71	3	0.24	21	0.35	20	0.70	3	0.24	21	0.37	20	0.69	3	0.25	19	0.36	20
coal	0.56	10	0.31	15	0.60	8	0.55	10	0.30	16	0.61	8	0.55	10	0.29	16	0.60	7
oil_shales	0.69	5	0.22	23	0.89	4	0.67	5	0.23	23	0.92	4	0.64	6	0.23	22	0.91	4
fer_met	0.41	19	0.43	4	0.39	19	0.40	18	0.43	5	0.40	19	0.40	18	0.41	6	0.39	19
non_fer_met	0.38	22	0.48	2	0.45	15	0.37	22	0.49	2	0.47	15	0.37	21	0.49	2	0.47	14
chem	0.40	20	0.39	10	0.42	16	0.40	19	0.37	10	0.43	16	0.40	19	0.36	9	0.42	16
machin	0.39	21	0.37	12	0.60	7	0.39	20	0.36	11	0.61	7	0.39	20	0.33	13	0.59	8
wood	0.47	16	0.37	11	0.49	13	0.47	15	0.35	13	0.49	13	0.47	15	0.33	14	0.47	12
build_mat	0.48	15	0.39	9	0.54	11	0.49	14	0.38	8	0.55	11	0.49	14	0.36	8	0.54	11
textiles	0.30	24	0.24	22	0.41	17	0.27	24	0.23	22	0.42	17	0.24	24	0.23	23	0.41	18
food	0.35	23	0.48	3	0.34	21	0.36	23	0.45	3	0.33	21	0.36	22	0.43	4	0.32	21
manuf_goods	0.45	17	0.39	8	0.47	14	0.46	16	0.38	9	0.48	14	0.47	16	0.36	10	0.46	15
constr	0.59	8	0.29	18	0.49	12	0.60	8	0.28	18	0.50	12	0.60	7	0.26	18	0.47	13
agr_prod	0.59	7	0.30	16	0.30	23	0.60	7	0.29	17	0.30	23	0.60	8	0.27	17	0.28	24
trans	0.55	11	0.35	14	0.56	9	0.54	11	0.35	14	0.57	9	0.54	11	0.34	11	0.57	9
comm_serv	0.80	1	0.16	25	0.56	10	0.80	1	0.17	25	0.56	10	0.79	1	0.16	25	0.55	10
trade_serv	0.73	2	0.20	24	0.22	25	0.73	2	0.20	24	0.22	25	0.72	2	0.20	24	0.22	25
non_manuf_serv	0.64	6	0.26	19	0.72	5	0.62	6	0.27	19	0.74	5	0.64	5	0.24	20	0.71	6
hous_serv	0.49	14	0.40	6	0.71	6	0.46	17	0.42	6	0.74	6	0.44	17	0.43	5	0.74	5
health_educ_serv	0.58	9	0.30	17	0.97	1	0.56	9	0.30	15	0.98	1	0.55	9	0.30	15	0.97	1
r_d_serv	0.51	13	0.36	13	0.96	2	0.51	13	0.36	12	0.95	2	0.52	12	0.34	12	0.92	3
fin_serv	0.42	18	0.42	5	0.90	3	0.38	21	0.44	4	0.94	3	0.35	23	0.45	3	0.95	2

Direct, indirect and induced effects of Type II GDP-output multipliers - continued

Industry	1980 Direct	Rank	Indirect	Rank	Induced	Rank	1981 Direct	Rank	Indirect	Rank	Induced	Rank	1982 Direct	Rank	Indirect	Rank	Induced	Rank	1983 Direct	Rank	Indirect	Rank	Induced	Rank
elec	1	20	3	23	2	22	1	19	3	22	2	22	1	19	3	20	2	21	1	19	2	20	2	21
oil_exc	0	22	3	19	2	24	0	22	3	19	2	24	0	22	3	19	1	24	0	22	2	21	1	24
oil_proc	0	25	4	13	2	23	0	25	4	13	2	23	0	25	3	13	2	23	0	25	3	13	2	23
gas	1	19	2	25	1	25	1	20	2	25	1	25	1	20	2	25	1	25	1	20	2	25	1	25
coal	5	13	3	20	4	13	5	13	3	20	4	13	5	12	3	15	3	12	5	12	3	14	3	13
oil_shales	20	1	3	17	6	5	19	2	3	17	5	5	18	2	2	24	4	8	16	2	2	24	4	8
fer_met	2	17	5	7	3	14	2	17	5	6	3	14	2	17	5	7	3	15	2	17	4	8	2	15
non_fer_met	1	21	3	16	3	20	1	21	3	15	3	19	1	21	3	14	2	19	1	21	3	15	2	22
chem	3	15	5	9	3	18	3	15	5	10	3	18	3	15	4	10	2	17	3	16	4	10	2	18
machin	9	8	7	5	4	10	8	8	6	5	4	11	8	8	6	5	3	11	8	8	5	5	3	11
wood	6	9	5	8	4	12	6	9	5	8	4	12	6	9	4	9	3	13	5	9	4	9	3	12
build_mat	5	14	4	12	3	15	4	14	4	12	3	15	4	14	4	12	3	14	4	14	3	12	3	14
textiles	6	11	9	2	3	17	6	10	8	2	3	17	5	11	7	2	2	18	5	10	7	3	2	17
food	2	18	7	3	2	21	1	18	7	3	2	21	1	18	7	3	2	22	1	18	7	2	2	20
manuf_goods	0	24	15	1	5	7	0	23	15	1	5	6	0	23	14	1	4	7	0	23	12	1	4	7
constr	5	12	3	15	5	6	5	12	3	14	5	7	5	13	3	16	5	6	5	13	3	16	4	6
agr_prod	13	3	7	4	4	9	13	4	7	4	4	9	12	4	6	4	4	10	11	4	5	4	3	10
trans	6	10	3	22	4	11	6	11	2	24	4	10	5	10	2	23	4	9	5	11	2	23	3	9
comm_serv	10	7	6	6	7	3	9	7	5	7	6	3	9	7	5	6	6	3	8	7	4	7	5	4
trade_serv	3	16	3	24	4	8	3	16	2	23	4	8	3	16	3	21	5	5	3	15	3	18	4	5
non_manuf_serv	19	2	4	11	3	19	22	1	4	11	2	20	25	1	4	11	2	20	25	1	4	11	2	19
hous_serv	11	6	3	21	8	1	11	6	3	21	7	1	11	5	3	22	6	1	10	5	2	22	6	1
health_educ_serv	12	4	3	18	6	4	13	3	3	18	6	4	14	3	3	18	6	4	14	3	3	17	5	3
r_d_serv	12	5	3	14	7	2	11	5	3	16	7	2	10	6	3	17	6	2	9	6	2	19	6	2
fin_serv	0	23	5	10	3	16	0	24	5	9	3	16	0	24	5	8	3	16	0	24	5	6	2	16

Industry	1984 Direct	Rank	Indirect	Rank	Induced	Rank	1985 Direct	Rank	Indirect	Rank	Induced	Rank	1986 Direct	Rank	Indirect	Rank	Induced	Rank	1987 Direct	Rank	Indirect	Rank	Induced	Rank
elec	1	19	2	21	2	22	1	19	2	22	2	22	1	19	2	21	2	22	1	19	2	17	2	22
oil_exc	0	23	2	22	1	24	0	23	2	21	1	24	0	23	2	20	1	24	0	23	2	21	1	24
oil_proc	0	25	3	13	2	21	0	25	3	13	2	21	0	25	3	13	2	21	0	25	3	13	2	21
gas	1	20	1	25	1	25	1	21	1	25	1	25	1	21	1	25	1	25	1	21	1	24	1	25
coal	5	12	3	14	3	10	5	13	3	14	3	10	4	12	3	14	3	10	5	11	3	15	3	10
oil_shales	15	2	2	24	4	8	14	3	2	24	4	8	13	3	2	24	3	8	14	3	1	25	3	8
fer_met	2	17	4	7	2	16	2	17	4	7	2	16	2	17	4	7	2	18	2	17	3	8	2	18
non_fer_met	1	21	3	16	2	23	1	20	3	15	2	23	1	20	3	15	2	23	1	20	2	18	2	23
chem	3	16	4	10	2	19	3	16	4	11	2	20	3	16	3	10	2	20	3	15	3	11	2	20
machin	7	8	5	5	3	13	7	8	4	5	3	13	6	7	4	5	2	13	6	7	4	6	2	13
wood	5	9	4	9	3	12	5	10	4	8	3	12	5	10	4	8	3	12	5	9	3	7	3	12
build_mat	4	14	3	12	3	14	4	14	3	12	2	14	4	14	3	12	2	14	4	14	3	12	2	14
textiles	5	10	7	2	2	17	5	9	7	3	2	18	5	9	6	3	2	19	5	10	5	3	2	19
food	1	18	7	3	2	20	1	18	7	2	2	19	2	18	8	2	2	16	1	18	7	2	2	15
manuf_goods	0	22	12	1	4	7	0	22	12	1	4	7	0	22	11	1	4	7	0	22	10	1	3	7
constr	5	13	3	15	4	6	5	11	3	16	4	6	4	11	2	17	4	6	4	12	3	14	4	5
agr_prod	10	4	5	4	3	11	10	5	5	4	3	11	9	5	4	4	3	11	9	5	4	4	3	9
trans	5	11	2	23	3	9	5	12	2	23	3	9	4	13	2	23	3	9	4	13	2	23	3	11
comm_serv	7	7	4	8	5	4	7	7	4	10	5	2	6	8	3	11	5	2	6	8	3	10	4	3
trade_serv	3	15	2	19	4	5	3	15	2	20	4	5	3	15	2	18	4	5	2	16	2	22	4	6
non_manuf_serv	25	1	4	11	2	18	28	1	4	9	2	15	28	1	4	9	2	15	29	1	3	9	2	17
hous_serv	10	5	2	20	6	1	10	4	2	18	6	1	10	4	2	19	5	1	10	4	2	20	5	1
health_educ_serv	14	3	3	17	5	3	15	2	3	17	5	3	16	2	2	16	5	3	16	2	2	16	5	2
r_d_serv	9	6	3	18	6	2	9	6	2	19	5	4	8	6	2	22	5	4	8	6	2	19	4	4
fin_serv	0	24	4	6	2	15	0	24	4	6	2	17	0	24	4	6	2	17	0	24	4	5	2	16

Table B.10: Direct, indirect and induced effects of Type II employment-output multipliers

Industry	1988 Direct	Rank	Indirect	Rank	Induced	Rank	1989 Direct	Rank	Indirect	Rank	Induced	Rank	1990 Direct	Rank	Indirect	Rank	Induced	Rank	1991 Direct	Rank	Indirect	Rank	Induced	Rank
elec	1	19	2	20	2	22	1	19	2	20	2	22	1	19	2	21	2	21	1	19	2	21	2	16
oil_exc	0	23	2	19	1	24	0	23	2	18	1	24	0	23	2	20	1	24	0	22	2	20	2	23
oil_proc	0	25	3	12	2	21	0	25	2	12	2	20	0	25	3	13	2	17	0	25	3	13	2	22
gas	1	21	1	25	1	25	1	21	1	25	1	25	1	21	1	25	1	25	1	21	1	25	1	25
coal	4	11	2	15	3	10	5	9	2	16	3	8	5	9	2	16	3	9	5	9	3	15	1	24
oil_shales	15	3	2	24	3	8	15	3	2	24	3	7	15	3	1	24	3	7	16	2	1	24	5	3
fer_met	2	17	3	8	2	17	2	17	3	8	2	16	2	17	3	8	2	16	2	17	3	10	2	14
non_fer_met	1	20	2	21	2	23	1	20	2	21	1	23	1	20	2	17	2	22	1	20	3	14	2	17
chem	2	16	3	10	2	20	2	15	3	10	2	21	2	15	3	12	2	23	2	15	3	12	2	20
machin	6	7	4	5	2	12	6	7	3	5	2	11	6	7	3	7	2	11	6	8	4	6	3	9
wood	5	9	3	7	2	11	4	10	3	7	2	10	4	11	3	9	2	13	4	11	3	8	2	13
build_mat	4	14	3	13	2	14	3	14	2	15	2	15	3	14	2	15	2	15	3	14	3	17	3	11
textiles	4	10	5	3	2	19	4	11	5	3	2	18	4	12	4	3	2	19	4	12	5	3	2	21
food	1	18	7	2	2	16	1	18	7	1	2	17	1	18	6	1	2	18	1	18	7	1	2	19
manuf_goods	0	22	10	1	3	7	0	22	5	2	2	13	0	22	6	2	2	12	0	23	6	2	3	10
constr	4	12	2	17	4	5	4	12	2	17	4	5	4	10	2	19	3	5	5	10	2	18	4	7
agr_prod	9	5	4	4	2	13	9	5	4	4	2	12	9	5	4	4	2	14	9	4	5	4	3	12
trans	4	13	2	23	3	9	4	13	2	23	3	9	4	13	2	22	2	10	4	13	2	22	3	8
comm_serv	5	8	3	9	5	4	5	8	3	9	4	4	5	8	3	10	4	4	7	7	3	9	6	1
trade_serv	2	15	2	22	3	6	2	16	2	22	3	6	2	16	2	23	3	6	2	16	2	23	2	15
non_manuf_serv	25	1	3	11	2	18	22	1	3	11	2	19	17	1	3	6	2	20	16	1	4	5	2	18
hous_serv	9	4	2	18	5	1	9	4	2	19	5	1	9	4	2	18	5	1	9	5	2	19	5	4
health_educ_serv	16	2	2	14	5	2	16	2	2	14	4	3	16	2	3	14	4	3	16	3	3	16	5	2
r_d_serv	8	6	2	16	5	3	7	6	2	13	4	2	8	6	3	11	5	2	8	6	3	11	4	6
fin_serv	0	24	4	6	2	15	0	24	3	6	2	14	0	24	3	5	3	8	0	24	4	7	4	5

Industry	1992 Direct	Rank	Indirect	Rank	Induced	Rank	1993 Direct	Rank	Indirect	Rank	Induced	Rank	1994 Direct	Rank	Indirect	Rank	Induced	Rank	1995 Direct	Rank	Indirect	Rank	Induced	Rank
elec	1	19	2	21	2	22	2	19	2	21	3	24	2	19	3	21	3	23	2	20	3	20	4	20
oil_exc	0	23	2	20	2	21	1	23	2	20	4	20	1	24	2	22	4	22	1	24	2	23	3	24
oil_proc	0	25	3	12	2	23	0	25	4	12	4	16	0	25	4	10	5	11	0	25	4	7	4	22
gas	1	21	1	25	1	25	1	22	1	25	1	25	1	23	1	25	2	24	1	23	1	25	2	25
coal	5	11	3	14	5	9	6	12	3	13	6	5	6	13	4	12	6	6	6	13	4	11	7	6
oil_shales	20	2	2	24	5	11	21	2	2	24	8	3	27	2	2	23	6	7	27	2	2	22	4	16
fer_met	2	16	4	10	3	16	2	16	4	11	4	19	3	16	4	13	4	19	2	17	3	15	4	21
non_fer_met	1	20	3	16	3	19	1	20	3	18	4	18	1	20	3	18	5	12	1	21	3	17	5	14
chem	3	15	4	9	3	17	3	15	4	10	3	21	4	15	4	9	4	18	4	15	4	10	4	18
machin	7	8	4	6	4	12	7	8	4	7	5	11	9	9	4	11	6	9	9	8	3	13	6	10
wood	5	10	4	8	4	13	6	10	4	8	6	7	8	10	5	4	7	3	7	10	4	6	6	9
build_mat	4	13	3	17	5	10	5	13	3	15	6	6	7	12	3	14	6	10	6	12	3	12	5	13
textiles	5	12	5	4	4	15	6	11	5	4	5	12	10	5	4	7	6	5	12	4	4	9	5	12
food	2	18	8	1	4	14	2	18	8	1	4	15	2	18	8	1	4	20	2	19	8	1	4	17
manuf_goods	1	22	7	2	5	8	1	21	7	2	8	2	1	21	7	2	9	2	2	18	6	3	8	3
constr	6	9	3	15	5	6	6	9	3	17	4	14	7	11	3	17	5	14	7	11	3	16	6	8
agr_prod	10	4	6	3	5	7	11	4	6	3	5	10	13	4	7	3	4	17	12	5	6	2	4	19
trans	4	14	2	22	3	20	5	14	2	22	3	22	5	14	3	20	5	15	6	14	3	19	6	11
comm_serv	7	7	3	13	6	4	8	7	3	14	4	13	9	8	3	15	1	25	7	9	3	18	7	7
trade_serv	2	17	2	23	2	24	2	17	2	23	3	23	2	17	2	24	4	21	3	16	2	24	3	23
non_manuf_serv	25	1	5	5	3	18	24	1	5	5	6	9	27	1	4	6	5	13	31	1	5	4	13	1
hous_serv	9	5	2	19	6	3	9	6	3	19	4	17	9	7	3	19	4	16	9	7	2	21	5	15
health_educ_serv	16	3	3	18	7	2	16	3	3	16	7	4	17	3	3	16	6	8	25	3	3	14	8	4
r_d_serv	9	6	4	11	13	1	9	5	4	6	10	1	9	6	5	5	10	1	9	6	5	5	8	2
fin_serv	0	24	4	7	6	5	1	24	4	9	6	8	1	22	4	8	6	4	1	22	4	8	8	5

Direct, indirect and induced effects of Type II employment-output multipliers - continued

	1996						1997						1998						1999					
Industry	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank
elec	2	20	3	20	4	20	2	19	3	16	3	20	2	18	3	17	4	19	2	17	3	17	4	13
oil_exc	1	24	2	23	3	22	1	24	2	23	3	22	1	24	2	22	3	21	1	24	2	22	3	22
oil_proc	0	25	3	11	3	23	0	25	3	14	3	23	0	25	3	13	3	23	0	25	3	10	3	23
gas	1	23	1	25	3	21	1	23	1	25	3	21	1	23	1	25	3	20	1	23	1	25	3	20
coal	6	13	3	9	8	3	6	13	3	9	8	3	6	12	3	9	8	5	5	13	3	12	9	4
oil_shales	28	2	2	22	6	10	27	2	2	21	7	6	30	2	2	24	8	4	26	3	2	21	7	6
fer_met	2	17	3	15	4	18	2	17	3	15	4	17	2	17	3	15	4	17	2	19	3	16	4	16
non_fer_met	1	21	3	18	6	9	1	21	2	20	5	13	1	21	2	20	4	16	1	21	2	20	3	19
chem	4	15	4	6	5	16	4	15	3	8	5	15	4	16	3	10	5	14	3	16	3	13	4	14
machin	9	7	3	10	6	11	8	7	3	13	6	11	8	7	3	11	6	7	7	9	3	9	6	11
wood	8	9	4	5	7	5	7	10	4	5	7	5	6	11	4	5	6	8	5	12	4	6	5	12
build_mat	7	12	4	7	5	13	6	12	3	7	6	12	6	13	4	7	6	11	6	10	3	7	6	9
textiles	13	4	3	16	5	14	12	4	3	19	4	18	12	5	3	16	5	15	10	5	3	14	4	15
food	2	18	7	1	4	17	2	18	7	1	5	16	2	19	8	1	4	18	2	18	7	1	4	18
manuf_goods	2	19	5	2	6	12	2	20	5	2	7	7	2	20	5	4	5	13	2	20	5	3	4	17
constr	7	11	3	14	6	8	7	9	3	11	6	8	8	9	3	12	6	10	7	8	3	11	6	10
agr_prod	12	5	5	4	4	19	11	5	5	4	4	19	12	4	5	2	3	22	12	4	5	2	3	21
trans	6	14	3	19	6	7	6	14	3	18	6	10	6	14	3	18	6	9	6	11	3	19	6	8
comm_serv	8	10	3	17	3	24	7	11	2	22	3	24	7	10	2	21	3	24	5	14	2	24	3	24
trade_serv	3	16	2	24	3	25	3	16	2	24	3	25	4	15	2	23	2	25	4	15	2	23	2	25
non_manuf_serv	36	1	3	13	7	6	34	1	3	12	6	9	35	1	3	8	7	6	37	1	3	8	8	5
hous_serv	10	6	3	21	5	15	10	6	3	17	5	14	10	6	3	19	6	12	10	6	3	18	6	7
health_educ_serv	26	3	3	12	8	2	26	3	3	10	7	4	26	3	3	14	8	3	26	2	3	15	9	3
r_d_serv	8	8	5	3	11	1	8	8	5	3	10	1	8	8	5	3	10	1	7	7	4	4	10	1
fin_serv	1	22	4	8	7	4	1	22	4	6	8	2	1	22	4	6	10	2	1	22	4	5	9	2

	2000						2001						2002						2003					
Industry	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank	Direct	Rank	Indirect	Rank	Induced	Rank
elec	6	12	3	18	4	13	6	12	3	19	4	15	6	11	2	18	4	19	6	9	2	17	4	18
oil_exc	1	22	2	22	3	23	1	22	2	22	3	21	1	23	2	22	3	21	1	23	2	22	3	22
oil_proc	0	25	3	14	2	24	0	25	3	14	3	23	0	25	3	15	3	24	0	24	3	13	2	24
gas	1	21	1	25	3	20	1	20	1	24	4	19	1	21	1	24	3	23	1	21	1	24	3	20
coal	7	8	3	7	7	5	7	7	3	4	6	6	7	6	3	4	6	7	7	6	3	6	5	8
oil_shales	32	2	3	19	9	2	35	2	3	15	14	1	34	2	3	13	13	1	32	2	3	5	8	4
fer_met	1	23	3	16	4	14	1	23	3	16	4	13	1	22	3	17	4	16	1	22	2	18	3	19
non_fer_met	0	24	2	21	4	18	0	24	2	21	4	14	0	24	2	21	4	14	0	25	2	21	4	15
chem	3	17	3	10	4	15	3	17	3	10	4	17	3	17	3	9	4	17	3	17	3	8	4	16
machin	8	6	3	8	5	9	8	6	3	6	6	8	7	7	3	8	6	8	7	8	3	9	5	7
wood	4	15	3	11	5	12	4	15	3	11	5	11	4	15	3	14	5	13	4	14	3	14	4	13
build_mat	5	14	3	9	5	10	5	13	3	9	5	10	5	13	3	7	5	9	5	11	3	11	5	11
textiles	10	5	3	17	4	16	9	5	3	18	4	18	9	5	3	16	4	18	8	5	2	16	4	17
food	2	18	5	1	3	19	2	18	5	1	3	20	2	18	4	1	3	20	2	18	4	1	3	21
manuf_goods	6	10	4	5	4	17	6	11	3	7	4	16	5	12	3	10	4	15	5	13	3	15	4	14
constr	4	16	3	15	5	11	4	16	3	17	5	12	3	16	2	19	5	12	3	16	2	20	4	12
agr_prod	8	7	4	4	3	21	7	9	3	5	3	22	6	9	3	5	3	22	5	10	3	10	3	23
trans	6	11	2	20	6	8	6	10	2	20	6	9	6	10	2	20	5	10	5	12	2	19	5	9
comm_serv	5	13	1	24	3	22	5	14	1	25	2	24	4	14	1	25	5	11	3	15	1	25	5	10
trade_serv	2	19	2	23	2	25	2	19	2	23	2	25	2	19	2	23	2	25	2	19	1	23	2	25
non_manuf_serv	39	1	3	6	7	6	40	1	3	8	6	7	42	1	3	11	6	6	45	1	3	7	6	5
hous_serv	14	4	3	13	6	7	15	4	3	12	7	5	16	4	3	6	6	5	16	4	3	4	6	6
health_educ_serv	30	3	3	12	8	4	30	3	3	13	8	2	29	3	3	12	9	3	30	3	3	12	9	1
r_d_serv	7	9	4	2	9	1	7	8	4	2	8	3	7	8	4	3	9	2	7	7	3	3	8	2
fin_serv	1	20	4	3	9	3	1	21	4	3	8	4	1	20	4	2	8	4	1	20	4	2	8	3

Direct, indirect and induced effects of Type II employment-output multipliers - continued

Industry	2004 Direct	Rank	Indirect	Rank	Induced	Rank	2005 Direct	Rank	Indirect	Rank	Induced	Rank	2006 Direct	Rank	Indirect	Rank	Induced	Rank
elec	6	8	2	15	3	18	6	7	2	14	3	18	6	6	2	14	3	17
oil_exc	0	23	2	22	3	22	0	23	1	22	3	22	0	23	1	22	2	22
oil_proc	0	25	2	13	2	24	0	25	2	12	2	24	0	25	2	9	2	23
gas	1	21	1	24	3	20	1	21	1	24	3	20	1	21	1	24	3	20
coal	6	7	2	7	5	8	5	8	2	9	5	8	5	8	2	7	4	7
oil_shales	29	3	3	5	8	4	28	3	3	5	7	4	27	3	3	2	7	4
fer_met	1	22	2	18	3	19	1	22	2	16	3	19	1	22	2	15	3	19
non_fer_met	0	24	2	21	4	15	0	24	2	21	4	15	0	24	2	20	4	14
chem	2	17	2	8	4	16	3	17	2	8	3	16	2	16	2	8	3	16
machin	5	9	2	9	5	7	5	9	2	10	5	7	5	9	2	12	4	8
wood	4	14	2	12	4	13	4	14	2	13	4	13	4	14	2	13	4	12
build_mat	5	11	2	10	5	11	4	11	2	11	4	11	4	11	2	10	4	11
textiles	8	5	2	17	3	17	8	5	2	17	3	17	7	5	2	17	3	18
food	2	18	3	2	3	21	2	18	3	2	3	21	2	18	2	5	2	21
manuf_goods	4	13	2	14	4	14	4	13	2	15	4	14	4	13	2	16	3	15
constr	3	15	2	20	4	12	3	15	2	20	4	12	2	15	2	21	4	13
agr_prod	5	10	2	16	3	23	5	10	2	18	2	23	4	12	2	19	2	24
trans	4	12	2	19	5	9	4	12	2	19	5	9	4	10	2	18	4	9
comm_serv	3	16	1	25	5	10	3	16	1	25	4	10	2	17	1	25	4	10
trade_serv	2	19	1	23	2	25	2	19	1	23	2	25	2	19	1	23	2	25
non_manuf_serv	48	1	2	6	6	5	49	1	2	6	6	5	46	1	2	11	5	6
hous_serv	16	4	3	4	6	6	15	4	3	4	6	6	14	4	3	3	6	5
health_educ_serv	31	2	2	11	8	1	31	2	2	7	8	1	30	2	2	6	7	1
r_d_serv	6	6	3	3	8	2	6	6	3	3	8	2	6	7	2	4	7	3
fin_serv	1	20	3	1	8	3	1	20	3	1	8	3	1	20	3	1	7	2

Direct, indirect and induced effects of Type II employment-output multipliers - continued

Appendix C. Supplementary material for Chapter 4

Year	REV_{tot} [a]	REV_{oilgas} [b]	$\frac{REV_{oilgas}}{REV_{tot}}$, %	$y_{e,oilgas}$ [c]	$CONV_{oilgas}$ [d]	$x_{tot,oilgas}$ [e]	$\frac{y_{e,oilgas}}{x_{tot,oilgas}}$, % [f]	$\frac{CONV_{oilgas}}{x_{tot,oilgas}}$, %
2005	5,127.30	2,162.10	42%	600.40	557.50	1,408.50	42.6%	39.6%
2006	6,278.90	2,943.50	47%	589.40	580.50	1,427.30	41.3%	40.7%
2007	7,781.10	2,897.40	37%	591.20	592.90	1,446.70	40.9%	41.0%
2008	9,275.90	4,389.40	47%	573.10	602.30	1,442.40	39.7%	41.8%
2009	7,337.80	2,984.00	41%	543.40	594.20	1,393.00	39.0%	42.7%
2010	8,305.40	3,830.70	46%	554.40	639.90	1,464.00	37.9%	43.7%
2011	11,367.70	5,641.80	50%	565.50	656.70	1,506.90	37.5%	43.6%
2012	12,855.50	6,453.20	50%	549.30	676.10	1,501.50	36.6%	45.0%
2013	13,019.90	6,534.00	50%	565.10	654.60	1,510.60	37.4%	43.3%
2014	14,496.90	7,433.80	51%	521.50	685.50	1,491.20	35.0%	46.0%
2015	13,659.20	5,862.70	43%	563.70	647.10	1,499.10	37.6%	43.2%

[a] Federal budget, billion Rubles

[b] Revenues from oil and gas, billion Rubles

[c] Export of oil and gas, Mtoe

[d] Use of oil and gas for conversion to other forms of energy resources and fuel, Mtoe

[e] Total distribution (use) of oil and gas, Mtoe

[f] Share of export to total distribution of oil and gas

Table C.1: Export quantity and distribution figures of oil and gas from 2005 until 2015

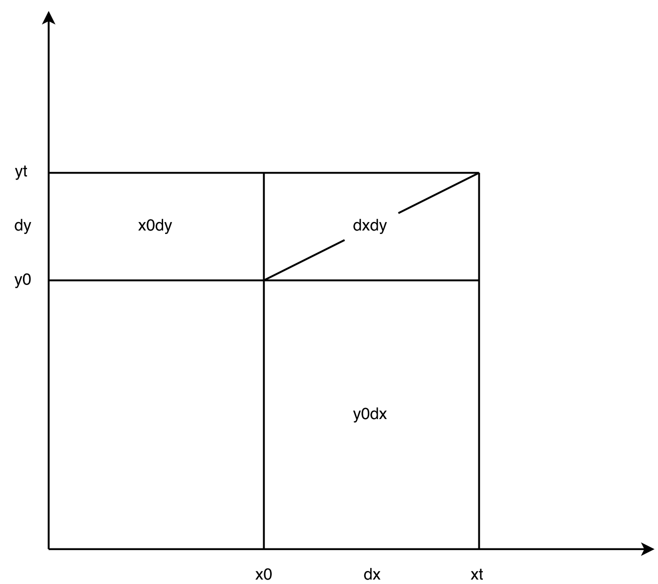
Proof of perfect decomposition of Shapley/Sun - Dietzenbacher/Los (S/S-D&L) decomposition method

Following Sun (1998), for simplicity we use a 2 factor model. Assume $V = xy$. We can represent the decomposition of V in time period $[0, t]$ as follows:

$$\Delta V = V^t - V^0 = x^t y^t - x^0 y^0 = (x^t - x^0) y^0 + (y^t - y^0) x^0 + (x^t - x^0)(y^t - y^0)$$

$$= y^0 \Delta x + x^0 \Delta y + \Delta x \Delta y$$

where $y^0 \Delta x$ and $x^0 \Delta y$ are the contributions of the change of factor x and y to the change of variable v, respectively. The last term $\Delta x \Delta y$ is the residual in the decomposition model. Figure below illustrates the process of change.



Schematic for S/S-D&L decomposition

The residual is attributed equally to both of the effects, and if one of them goes to zero, the other effect disappears also. We assume there is an equal contribution of x and y effects.

$$V_x = y^0 \Delta x + \frac{1}{2}\Delta x \Delta y$$

$$V_y = x^0 \Delta y + \frac{1}{2}\Delta x \Delta y$$

Therefore, the total decomposition is $\Delta V = V_x + V_y$. If there are 3 factors in the model $V = xyz$, the contributions of individual effects to $V = V_x + V_y + V_z$ can be represented as follows:

$$V_x = y^0 z^0 \Delta x + \frac{1}{2}\Delta x (z^0 \Delta y + y^0 \Delta z) + \frac{1}{3}\Delta x \Delta y \Delta z$$

$$V_y = x^0 y^0 \Delta z + \frac{1}{2}\Delta y (z^0 \Delta x + x^0 \Delta z) + \frac{1}{3}\Delta x \Delta y \Delta z$$

$$V_z = x^0 y^0 \Delta z + \frac{1}{2}\Delta z (y^0 \Delta x + x^0 \Delta y) + \frac{1}{3}\Delta x \Delta y \Delta z$$

In n-dimensional space, i.e. $V = x_1 x_2 ... x_n$, the individual contributions can be detailed as $\Delta V = n$ terms with one term of Δ (Δx_i, for $i = 1, 2, ..., n$) + $\frac{n(n-1)}{2!}$ terms with two orders of Δ ($\Delta x_1 \Delta x_1$) + $\frac{n(n-1)(n-2)}{3!}$ terms with three orders of Δ ($\Delta x_1 \Delta x_2 \Delta x_3$ + ... + one term $\frac{n(n-1)(n-2)...2*1}{n!}$ with n orders of Δ ($\Delta x_1 \Delta x_2 ... \Delta x_{n-1} \Delta x_n$). The individual effect for the factor i can be represented in the following general formula:

$$X_{ieffect} = \frac{V^0}{x_i^0} + \sum_{i \neq j} \frac{V^0}{2 x_i^0 x_j^0} \Delta x_i \Delta x_j + \sum_{i \neq j \neq \gamma} \frac{V^0}{3 x_i^0 x_j^0 x_\gamma^0} \Delta x_i \Delta x_j \Delta x_\gamma + ... + \frac{1}{n} \Delta x_i \Delta x_2 ... \Delta x_n$$

which can be re-written as follows:

$$\Delta V_i = \sum_{i \in S \subseteq N, |S| = s} \frac{(s-1)!(n-s)!}{n!} [v(S) - v(S-i)]$$

where $N = 1, 2, ..., n$ and $v(S) = \sum_{S \subseteq N, j=1}^{m} \prod_{p \in S} x_{j,p}^t \prod_{q \in N-s} x_{j,q}^0$.

Table C.2: Direct and embodied emissions, Gg-CO2

Direct and embodied emissions in 1992, Gg-CO2

Industry cluster	C_{pc}	C_{gc}	C_{gcf}	C_{ex}
Agriculture	121,023.03	9,844.32	764.93	4,272.88
Primary Energy	1,997.33	-	4,687.35	98,135.69
Petroleum	4,999.26	-	-83,382.36	19,750.97
Manufacturing	112,726.39	266.44	155,174.31	108,607.44
Food	153,605.71	19.90	3,935.80	7,050.61
Electricity	214,698.54	70,664.46	-	6,946.50
Construction	1,296.65	-	273,445.94	4,204.31
Trade	76,815.57	293.54	23,026.33	51,787.19
Transport	99,363.13	5,089.72	76,343.99	61,113.14
Business Services	22,902.07	49,297.35	20,496.94	18,591.05
Public Services	18,298.45	211,577.83	0.00	3,347.61
Embodied CO_2	827,726.11	347,053.56	474,493.23	383,807.38
Household direct CO_2	146,742.30			
Total CO_2	974,468.41	347,053.56	474,493.23	383,807.38

Direct and embodied emissions in 1996, Gg-CO2

Industry cluster	C_{pc}	C_{gc}	C_{gcf}	C_{ex}
Agriculture	93,862.38	4,591.82	5,827.29	1,314.76
Primary Energy	1,986.98	-	-2,512.89	89,792.88
Petroleum	5,998.73	-	-12,460.23	27,977.87
Manufacturing	83,055.18	143.65	9,938.55	189,643.25
Food	107,825.83	13.51	669.39	5,623.67
Electricity	160,108.35	52,992.83	-	8,645.88
Construction	725.63	-	141,427.45	3,003.16
Trade	69,501.31	268.15	18,629.40	48,744.82
Transport	80,719.02	3,270.73	41,354.54	53,420.66
Business Services	21,604.86	41,405.06	17,177.56	20,087.89
Public Services	19,803.23	166,301.61	-0.00	2,684.37
Embodied CO_2	645,191.50	268,987.36	220,051.05	450,939.21
Household direct CO_2	94,448.00			
Total CO_2	739,639.50	268,987.36	220,051.05	450,939.21

Direct and embodied emissions in 2000, Gg-CO2

Industry cluster	C_{pc}	C_{gc}	C_{gcf}	C_{ex}
Agriculture	71,446.69	4,555.62	-2,031.47	1,077.20
Primary Energy	1,864.12	-	10,905.43	101,378.79
Petroleum	7,516.58	-	-26,837.74	27,814.63
Manufacturing	73,177.83	153.75	51,637.52	183,684.13
Food	111,320.10	11.32	-10,195.78	5,100.71
Electricity	141,847.13	50,644.07	-	7,446.53
Construction	638.50	-	116,517.82	2,919.84
Trade	56,528.02	296.06	12,978.73	48,434.18
Transport	63,393.77	2,185.02	47,961.96	64,252.20
Business Services	21,226.73	36,306.86	21,672.35	23,251.88
Public Services	24,607.46	154,471.85	0.00	3,308.58
Embodied CO_2	573,566.93	248,624.54	222,608.83	468,668.67
Household direct CO_2	100,672.80			
Total CO_2	674,239.73	248,624.54	222,608.83	468,668.67

Direct and embodied emissions in 2008, Gg-CO2

Industry cluster	C_{pc}	C_{gc}	C_{gcf}	C_{ex}
Agriculture	53,264.35	1,025.55	1,112.20	9,233.15
Primary Energy	2,025.58	-	-2,787.86	104,837.23
Petroleum	10,057.38	-	8,832.93	44,887.87
Manufacturing	68,788.88	708.67	73,160.83	179,577.43
Food	102,666.33	5.77	-15,247.54	8,995.64
Electricity	148,452.62	56,858.76	-	13,790.82
Construction	901.27	-	139,502.73	1,700.43
Trade	99,112.73	284.70	23,412.85	58,112.41
Transport	100,637.83	6,396.18	53,380.62	58,706.62
Business Services	38,559.90	28,435.51	15,376.36	23,082.26
Public Services	26,734.81	127,003.19	0.00	3,412.50
Embodied CO_2	651,201.67	220,718.32	296,743.12	506,336.35
Household direct CO_2	96,371.20			
Total CO_2	747,572.87	220,718.32	296,743.12	506,336.35

Direct and embodied emissions in 2013, Gg-CO2

Industry cluster	C_{pc}	C_{gc}	C_{gcf}	C_{ex}
Agriculture	67,771.78	1,047.32	-10,666.54	9,167.34
Primary Energy	2,937.03	-	-5,933.86	107,127.59
Petroleum	16,868.46	-	2,013.27	57,943.28
Manufacturing	71,197.44	817.66	54,345.10	187,399.49
Food	103,587.24	5.51	-16,152.58	9,351.95
Electricity	166,896.33	79,461.04	-	24,973.12
Construction	995.89	-	125,445.73	1,435.20
Trade	115,567.03	273.48	21,954.13	62,349.42
Transport	109,291.71	11,727.96	44,605.89	65,852.72
Business Services	40,700.53	22,418.75	17,898.08	20,406.58
Public Services	28,404.34	119,873.61	-0.00	4,757.58
Embodied CO_2	724,217.77	235,625.32	233,509.22	550,764.26
Household direct CO_2	101,616.90			
Total CO_2	825,834.67	235,625.32	233,509.22	550,764.26

Table C.3: Structural decomposition analysis of emission changes for Russia, Gg-CO2

Period	ΔC_{tot}	ΔC_{ecof}	ΔC_{emix}	ΔC_{gint}	ΔC_{lstr}	ΔC_{ystr}	ΔC_{ytot}
1992-1996	-447,911.16	-33,298.13	35,742.98	62,960.03	-42,397.47	8,120.52	-479,039.09
1996-2000	-71,700.16	-57,176.67	-50,106.12	37,106.65	-167,677.24	4,021.84	162,131.38
2000-2008	161,530.50	-68,620.18	193,302.27	-335,554.49	-575,854.85	-79,311.15	1,027,568.90
2008-2013	69,117.11	240,925.55	-102,469.98	-107,305.07	-126,441.51	14,805.74	149,602.39

SDA of emission changes embodied in household final demand for Russia, Gg-CO2

Period	ΔC_{tot}	ΔC_{ecof}	ΔC_{emix}	ΔC_{gint}	ΔC_{lstr}	ΔC_{ystr}	ΔC_{ytot}
1992-1996	-182,534.61	-18,926.89	20,316.55	35,786.91	-70,992.71	-17,237.99	-131,480.50
1996-2000	-71,624.57	-26,514.19	-23,235.40	17,207.24	-51,069.55	-11,223.59	23,210.92
2000-2008	77,634.74	-23,554.87	66,353.81	-115,183.95	-204,970.42	-106,892.42	461,882.60
2008-2013	73,016.10	59,565.27	-25,334.18	-26,529.59	-38,302.05	-16,357.72	119,974.38

SDA of emission changes embodied in government final demand for Russia, Gg-CO2

Period	ΔC_{tot}	ΔC_{ecof}	ΔC_{emix}	ΔC_{gint}	ΔC_{lstr}	ΔC_{ystr}	ΔC_{ytot}
1992-1996	-78,066.20	4,255.16	-4,567.59	-8,045.65	9,207.26	13,822.22	-92,737.60
1996-2000	-20,362.82	-6,342.92	-5,558.55	4,116.45	-12,910.47	-2,961.65	3,294.33
2000-2008	-27,906.21	-4,490.68	12,650.19	-21,959.54	-67,108.21	28,110.54	24,891.48
2008-2013	14,907.00	52,597.35	-22,370.60	-23,426.17	-10,511.45	22,492.12	-3,874.24

SDA of emission changes embodied in gross capital formation final demand for Russia, Gg-CO2

Period	ΔC_{tot}	ΔC_{ecof}	ΔC_{emix}	ΔC_{gint}	ΔC_{lstr}	ΔC_{ystr}	ΔC_{ytot}
1992-1996	-254,442.18	-9,239.09	9,917.45	17,469.25	2,523.93	-12,052.56	-263,061.16
1996-2000	2,557.78	-8,675.63	-7,602.79	5,630.33	-30,555.36	5,767.48	37,993.75
2000-2008	74,134.29	-17,646.09	49,708.85	-86,289.87	-140,561.37	16,362.98	252,559.80
2008-2013	-63,233.90	101,514.25	-43,175.84	-45,213.11	-36,833.99	-1,490.80	-38,034.41

SDA of emission changes embodied in foreign final demand for Russia, Gg_CO2

Period	ΔC_{tot}	ΔC_{ecof}	ΔC_{emix}	ΔC_{gint}	ΔC_{lstr}	ΔC_{ystr}	ΔC_{ytot}
1992-1996	67,131.83	-9,387.32	10,076.56	17,749.52	16,864.05	23,588.85	8,240.17
1996-2000	17,729.45	-15,643.93	-13,709.38	10,152.64	-73,141.85	12,439.60	97,632.38
2000-2008	37,667.68	-22,928.53	64,589.42	-112,121.13	-163,214.84	-16,892.25	288,235.02
2008-2013	44,427.92	27,248.67	-11,589.35	-12,136.20	-40,794.01	10,162.14	71,536.67